Surprise Attack:
PAGE 64 PV-1 Venturas

AIR&SPACE
Smithsonian

ALPINE CLIMBERS
HOW AIRPLANES BOOST A BRAND

MACH-BUSTING BIZJETS

62,000 MILES HIGH
A BEANSTALK TO ORBIT

GET LOST!
(BETCHA CAN'T)
PAGE 50

FAIRCHILD DORNIER
ALPHA JETS

MARCH 2006

Brains Conquer Beauty

Scientists break code to create perfect gemstones with even more fire and brilliance than mined diamonds.

There is little doubt that a natural mined diamond of top quality is one of the world's most magnificent gems. It is much coveted for its exquisite beauty, but the simple truth is that diamonds are just compressed crystallized carbon. The laboratories at Diamond*Aura* were created with one mission in mind: Design classic jewelry with scientifically perfect gemstones at a cost that lets everyone experience a stone with more fire and brilliance than a mined diamond.

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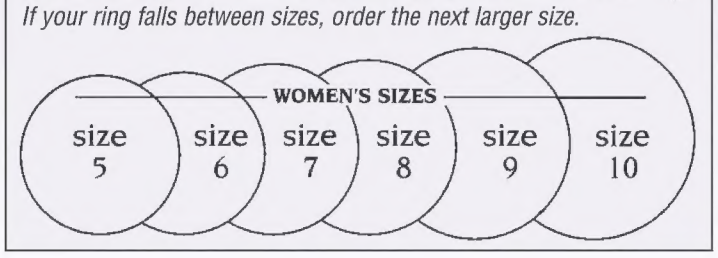

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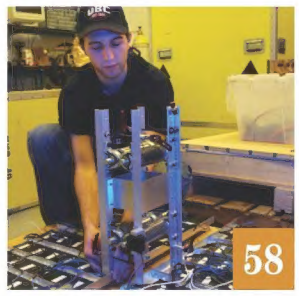

Cover: *To lush up the colors of Flying Bulls Alpha Jets, air-to-air genius Katsuhiko Tokunaga caught them between his photo plane, a Saab J-105OE, and the deep green of the Austrian Alps.*

DEPARTMENTS

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The Wright *Flyer*'s Encore

No event could have been more significant for the National Air and Space Museum than the centennial of the invention of the airplane. The year 2003 was a blur of ceremonies, public programs, lectures, books, articles, documentaries, exhibits, and other observances, celebrating and educating the public about the world-changing achievement of Wilbur and Orville Wright and the century of aerospace advances that followed. Enthusiasm for the year-long celebration burst from all over the globe, and the National Air and Space Museum was a focal point for anyone wanting to join the party.

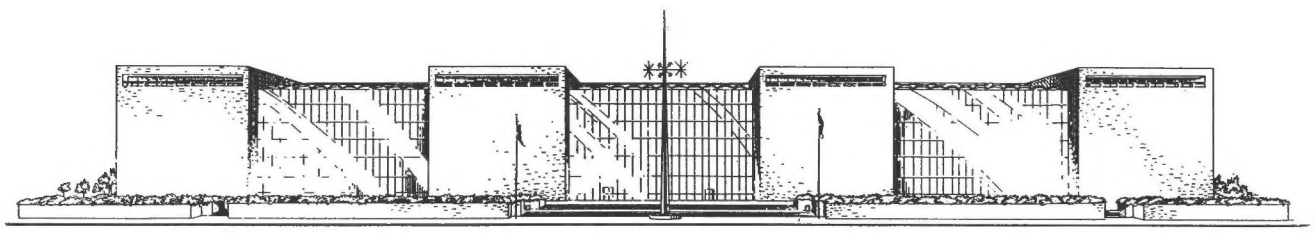
The Museum crowned its celebration of the centennial of flight with the opening of the Steven F. Udvar-Hazy Center in December 2003. At the ceremony held to open the center, a full-size reproduction Wright *Flyer* soared over the audience to trip a curtain and give our guests their first view of the spectacular new showcase of aerospace treasures. It was a breathtaking moment and a great day to be part of aviation.

Throughout 2003, excitement built as we all anticipated the opening of the Udvar-Hazy Center, but at NASM's flagship building on the National Mall, the centerpiece program was the opening of the exhibition "The Wright Brothers & The Invention of the Aerial Age" in October. Many organizations and individuals were working hard on plans to tell the Wright story in 2003—several built reproduction Wright *Flyer*s. But the National Air and Space Museum had a unique advantage over everyone. We have the original Wright airplane, the actual machine that carried Orville Wright into the air at 10:35 a.m. on December 17, 1903, beginning the era of powered flight. Armed with this ultimate aviation treasure, the Museum set about creating the most comprehensive exhibition on the Wright brothers and the invention of the airplane ever mounted. We displayed an unprecedented assemblage of Wright-related artifacts—170 in all—gathered from our own collection and loaned from museums and individuals across the United States and Europe.

One key to the immense popularity of the Wright brothers gallery is the opportunity to see the *Flyer* at eye level from just a few feet away. Always exhibited hanging since the Smithsonian acquired it in 1948, for this special presentation the Wright *Flyer* was placed in its own gallery, on the floor, so visitors could get a close look at every detail of the amazing machine. In this setting, the *Flyer* offers a powerful experience. If any inanimate object can be said to have charisma, this is the one.

"The Wright Brothers & The Invention of the Aerial Age" was planned as a two-year exhibition. In October 2005, the Wright *Flyer* was to return to its place of honor in the center of the Milestones of Flight gallery. But in light of its great popularity with the public, we have decided to extend the exhibition for another year. If you thought you missed your chance to see the Wright *Flyer* up close, you're in luck. The exhibit remains on view, providing an exciting and informative window on the endlessly fascinating Wilbur and Orville Wright and the airplane that started it all.

—J.R. Dailey is the director of the National Air and Space Museum.



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LETTERS

The Legendary Hustler

Since the B-58 was a strategic bomber, its contribution needs to be seen in more than operational and technical terms ("Speed Freak," Dec. 2005/Jan. 2006). The United States putting two wings of B-58s in service in the 1960s propelled the Soviet Union to pursue the same objective for two more decades. The Soviet project consumed massive resources within the Tupolev and Turmanski design bureaus, whose talents might well have been better used in other pursuits that would have put America at a disadvantage. The paranoia that the B-58s created just by sitting silently on alert easily rivals the political/economic impact of most any other planes we built, flying at any speed.

It can be argued that, within the confines of their own strategic doctrine, the Soviets created a counterpart to every U.S. airborne system except two—the SR-71 and the B-58—and spent themselves into oblivion doing it. Going nowhere fast, the B-58 played a major part in America's cold war victory.

John G. Rodman
Tiverton, Rhode Island

The Hustler made an impression on my family during the October 1962 Cuban Missile Crisis. Every afternoon around 4 p.m., we heard the BOOM BOOM of a supersonic aircraft flying overhead, but when we went outdoors and looked up, we never saw anything. Dad assumed they were bombers flying to Cuba to start bombing if the call was made. I found out years later that the B-58 was the only aircraft of the time able to fly supersonic on a regular basis and that during the weeklong crisis, it was making special reconnaissance flights over Cuba.

Steve Myrick
Houston, Texas

It is false to state "that the way to overcome drag in supersonic flight is to sweep the wings at such an angle that the aircraft flies within the Mach cone…so that the airflow over them remains subsonic." Airflow behind an oblique shock wave—i.e., a Mach cone—continues to be supersonic. Oblique shock waves continue to be generated by the engine nacelles, the wing leading edges, the vertical tail, and anything else causing a sudden change in airflow direction at supersonic speeds.

In 1962, I flew in the third station of the B-58, testing the escape capsule, and I saw the shock wave attached to the inlet leading edge of the number-two engine nacelle, which is well within the primary Mach cone. The shock wave from that station becomes quite visible at speeds above about Mach 1.5. It continues to lay back at a more reduced angle as the Mach number increases.

Robert Sudderth
Mineola, Texas

Editors' reply: We regret the error, which was introduced during editing.

Between 1960 and 1964, I served as Strategic Air Command Headquarters' B-58 Project Officer for Aircraft Systems. Early in the encapsulated-seat program, human factors engineers found that a brown bear, when seated, has roughly the same internal organ arrangement, spinal configuration, and center of gravity as most men. Thus, bears were the first subjects to be ejected. During these tests, powerful explosives shot the capsules up well enough. However, they accelerated so violently that the bears suffered compression fractures of their spines. The advent of better solid propellants and shaped charges allowed development of a dual-manifold rocket system. The new devices enabled the capsule's upward progress to begin more slowly (speaking in milliseconds), so the seat cushions and occupant's butt could compress.

Lt. Col. Hank Cervantes
U.S. Air Force (ret.)
Marina del Rey, California

While I was stationed at U-Tapao airfield in Thailand in 1973, an old sergeant told me that after the great Alaska earthquake of 1964, the 43rd Bomb Squad at Carswell Air Force Base in Texas launched B-58s with photo equipment. Sure enough, I recently found confirmation of the story on the Web (*www.globalsecurity.org/wmd/agency/43bw.htm*): "Members of the 43rd flew two B-58s the 5,751 miles

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LETTERS

to Alaska and back, processed the film, and then delivered the pictures to Washington DC 14.5 hours after the wing received the request."

John M. Fredrickson
Kent, Washington

Readers can catch brief glimpses of the B-58 in flight by viewing Sidney Lumet's 1964 movie *Fail Safe*. Hollywood enlarged the cockpit to allow pilot and copilot to sit side by side, and in front of the engineer/weapons officer. It also drastically improved the Hustler's endurance, permitting it to fly low-level, high-speed missions from North Dakota to Moscow without the need for mid-air refueling.

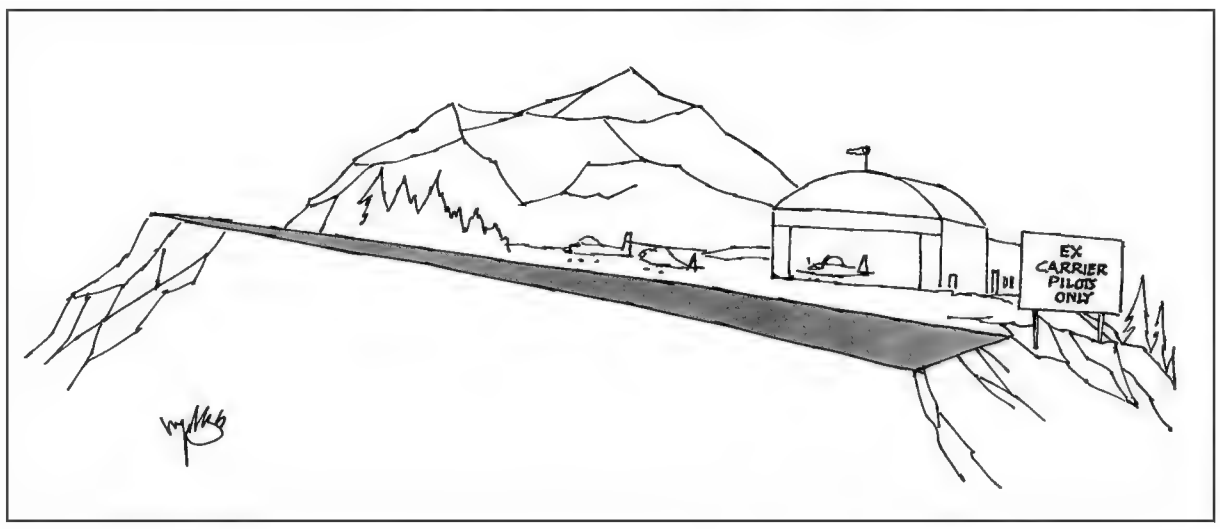
Stephen M. Hashioka
Chicago, Illinois

too late to experience B-47 bomb delivery via LABS—low-altitude bomb system ("A Full Retaliatory Response," Oct./Nov. 2005). As a former B-47 pilot, I can tell you that before the pop-up maneuver Cassiday describes, we did indeed use an Immelmann (actually a half Cuban Eight) to deliver weapons. The program was halted when the airplane began to shed its wings.

Maj. David W. Thomas
U.S. Air Force (ret.)
via e-mail

Dive Queen, Your Reign Is Over

There's more to the story of the abandoned 747 ("Missing in Inaction," Soundings, Dec. 2005/Jan. 2006). N4522V



Dose Adjustment

As a nuclear power plant operator, I noted that "The Invisible Killers" (Dec. 2005/Jan. 2006), states that from liftoff to splashdown, the Apollo 14 mission gave each crew member an average radiation dose of 1,140 mrem; the story further states that this amount is three times what the average Earth-bound human is exposed to from natural background sources each week. Actually, the average dose from background sources is about 350 mrem per year, not per week. (This figure varies, depending on geological composition, altitude, position on Earth, method of home construction, and the weather conditions an individual is exposed to.)

Jim George
Petersburg, Michigan

Give the Immelmann Its Due

From his letter ("No Immelmann for Us," Dec. 2005/Jan. 2006), it's evident that Col. Cassiday entered the B-47 program

is none other than the famous *Dive Queen*. On February 19, 1985, while being operated by China Airlines, the aircraft made a high dive over the Pacific, descending from 41,000 to 9,500 feet and pulling as much as 5.1 Gs during the recovery. After the plane landed safely in San Francisco, investigators found significant structural damage, including the ripping of an auxiliary power unit from its mountings and a permanent two-inch "set" in the wing dihedral. Miraculously, the incident resulted in no fatalities and few injuries.

After that, *Dive Queen* soldiered on for many years, providing a variety of services to various operators. As Huber reports, the current owners of *Dive Queen* are now on the run from creditors, maintenance facilities, charter clients, and the Federal Aviation Administration. Huber goes on to lament the decline of the U.S. airline industry and cites the falling fortunes of many aircraft in the fleet. Perhaps none has fallen as far as *Dive Queen*.

Steve Johnson
Weston, Florida

The Turkey Missile Crisis

"A Full Retaliatory Response" (Oct./Nov. 2005) should have mentioned that beginning a year prior to the 1962 Cuban Missile Crisis, Premier Nikita Krushchev warned U.S. government officials at all levels that unless the United States removed nuclear missiles we had placed in Turkey (and which were aimed at USSR cities), the USSR would be forced to retaliate by placing in Cuba missiles aimed at U.S. cities. Nor did your article mention that the USSR "backed down" only after the United States promised to remove the Turkey-based missiles.

The "USSR backs down" story was excellent stagecraft and it played well in Peoria, but it was the subject of much scorn in Europe, where people have access to foreign newspapers and radio.

Robert F. Kelley
Mashpee, Massachusetts

The Raptor Arrives, Missing a Letter

"The Raptor Arrives" (Oct./Nov. 2005) gives the Raptor's designation as "F/A-22." While this was correct at the time of publication, the designation has now been changed to "F-22" after extensive lobbying by the U.S. Air Force, which felt the "F/A" was too "Navy."

Roger Curtiss
Newbury, Ohio

Corrections

Dec. 2005/Jan. 2006 "Frozen in Time": The DC-4 uses 14-cylinder Pratt & Whitney R-2000 engines, not 18-cylinder R-2800s.

Letters: The letter attributed to Michael R. Pablo of the National Aeronautic Association was actually written by reader Ronald L. Wagner. We regret the mixup.

Write to us at Letters, Air & Space/ Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012. Please type or print clearly. You must include your full address and your daytime phone number.*

Note our new e-mail address: editors@si.edu. *You must include your full name, mailing address, and daytime phone number.*

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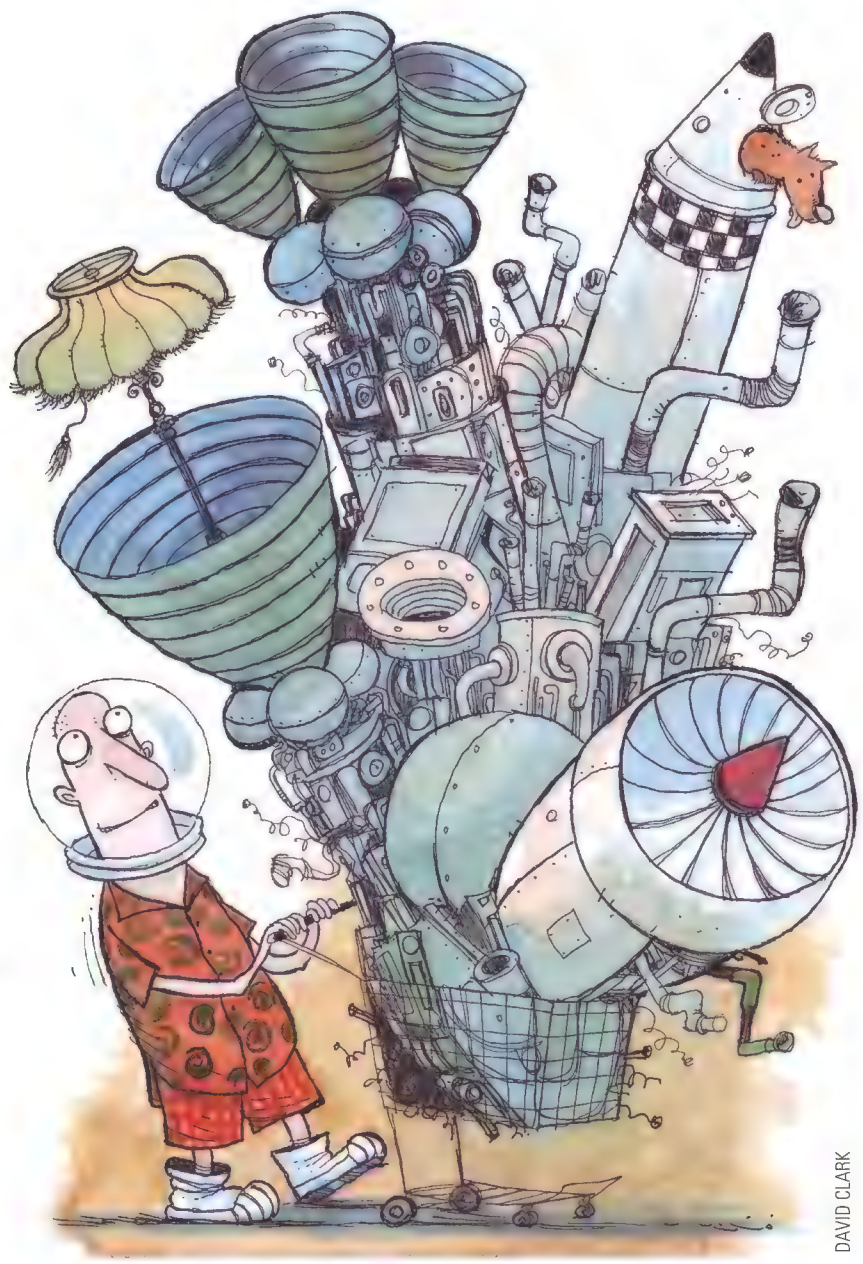
All letters selected for publication are edited. We regret that we cannot respond to every letter.

A Gauge Is a Gauge Is a Gauge



DAVID CLARK

Having trouble finding a Saturn-issue J-2 impeller turbine pump still in its 1964 shipping container? How about a titanium reaction control system fuel tank earmarked for the Apollo program? Or an Atlas MA-5 thrust chamber? Or a Gemini SE-6 mini-thruster?

If rare aerospace hardware is your passion, then Norton Sales ought to be one of your favorite haunts. Don't be misled by the homely storefront or the chaotic pack-rat profusion of industrial components rising to the rafters—and overflowing into a giant storage yard—of the 10,000-square-foot depot in North Hollywood, California. Owner Carlos Guzman sells everything from vacuum-jacketed stainless steel bellows designed for liquid oxygen to the only service propulsion system lunar command module rocket motor in the public domain.

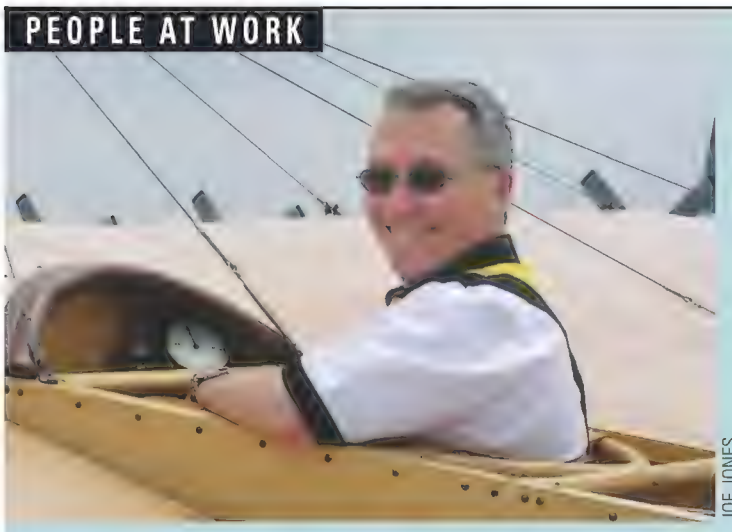
"He's got an unbelievably diverse agglomeration of historical artifacts," says Scott Schneeweis, a Navy lieutenant stationed in Pearl Harbor whose collection of Apollo hardware features a command module waste disposal selector valve he bought from Guzman. "He has so much stuff that I'm not sure even he knows everything he's got."

Guzman's bread-and-butter business is surplus hydraulics—pumps, solenoids, valves, and the like. "Electronics go out of style in a week," he says. "But a gauge is still a gauge and a flow meter is still a flow meter, no matter how old it is." He also does a lot of business with filmmakers, renting props and supplying stunt equipment.

Thanks to its large collection of motors and ancillary equipment, Norton Sales has a long history with the rocket community. But with space artifacts emerging as collectibles, the shop has also become a cult favorite with collectors who have targeted Space Age hardware.

The late Norton Holstrom, who founded the company, started dealing in surplus rocket components nearly 50 years ago, when southern California was the center of the aerospace universe and local craftsmen cranked out countless industrial artifacts worthy of museum display. After his son, Norton Holstrom Jr., joined the company, Norton Sales grew into two warehouses and three acres of outdoor storage. "They were just full of crap,"

PEOPLE AT WORK



JOE JONES

Avery, a jet guy, tries on a replica Blériot on display at the Las Vegas airshow.

The Best Jobs in Aerospace

Bob Avery, President, Aviation Nation Foundation, Las Vegas, Nevada

As an ex-F-15 Eagle pilot, I never wanted to be too far removed from my comrades and those fighters.

I joined the Aviation Nation founding team in 2001 with the shared vision of developing what we hoped would be one of the Air Force's most entertaining aviation events. The non-profit Aviation Nation Foundation handles all non-military components of the airshow, including marketing, promotion, media creation, community and commercial partnerships, volunteers, VIP activities, and public transportation. We also produce Las Vegas Air Racing, a demonstration of the world's fastest motorsport. Aviation Nation, the Nellis Air Force Base-Las Vegas Airshow, is now recognized as one of largest and most diverse airshows in North America. More than 150 classic, historical, and frontline military aircraft, including the F-22 Raptor, thrill 150,000 enthusiasts every year.

On my days off, I fly a McDonnell Douglas MD-11 around the world for Federal Express.

WORK IN PROGRESS

Tunnel Vision

Scientists at NASA's Langley Research Center in Hampton, Virginia, have their hands full crafting a flying wing of a new sort, a blended wing body. A five percent scale model BWB was recently tested in the full-scale wind tunnel's massive 30- by 60-foot test section. The 80-pound model, with a 12-foot wingspan, is the largest ever free-flight tested in the tunnel, which was completed in 1931 and has tested everything from World War II fighters to the Mercury capsule to supersonic transport concepts.

NASA and Boeing Phantom Works are working together to produce a military aircraft that is more fuel-efficient and can carry out many roles. The BWB lacks a conventional tail to control pitch and yaw. Instead, it employs a combination of control surfaces on the wing trailing edge. Free-flight tests will assess the best combination of such surfaces. "We're comfortable with the flight characteristics of conventional tube-with-wings airplanes," says Dan Vicroy, BWB flight dynamics principal investigator, "but we don't have much experience with flying wings."

The model had to be dynamically scaled—that is, it had to have the same scaled shape as the real deal, as well as the scaled weight and inertial characteristics of roll, pitch, and yaw, which in turn required the model to be extremely lightweight. It's constructed of graphite composite material, similar to that used to build Formula One race cars.

NASA LANGLEY

A blended wing body goes for a spin in a Langley wind tunnel.

Holstrom recalls. "Sometimes, we'd load two or three trucks a day."

Father and son bought surplus goodies at auction from coast to coast. They often bid on lots filled with stuff they don't want—or can't identify, which sometimes paid unexpected dividends. At one auction, for instance, they bought several dozen Atlas igniters for about a buck apiece; some 20 years later, they sold the units for nearly $4,000 per. And when items went unsold, Holstrom got creative. "I put an aircraft carrier landing light in my uncle's backyard," he says, "and it worked great."

Guzman, who had worked at Norton Sales for 12 years, bought the company in 2005. Hydraulics remain his core business, and Guzman himself reconditions many of the units. But it's the aerospace gear that makes the place unique. It's not only collectors who want it, but also aerospace professionals, who often buy components just to reverse-engineer them.

Guzman promotes some of his wares online in an eBay store; at the moment, a main fuel valve manufactured for Rocketdyne in 1957 is selling for $150. But the really good stuff is still in North Hollywood—a complete J-2, for example, and a dwindling supply of LR-101 rocket motors. Holstrom says he once had so many in stock that he used them as lamp bases. Now they sell to collectors for $7,000 a pop, and they're still a bargain.

"I get calls every day from England, from Australia, from everywhere around the world," Guzman says. He pats his prized Apollo SPS motor. "This isn't just history; this is art."

—Preston Lerner

A Tiny Fraction of a League Under the Sea

Future exploration of the solar system is often cast as belonging to either robots or astronauts. But the two factions are coming to the conclusion that to gain a permanent foothold off the planet, they need each other.

The realization is being encouraged on a patch of sand in the Florida Keys, 65 feet underwater, in the research facility Aquarius, an 80-ton chamber, 43 feet long and nine feet in diameter, that is owned by the National Oceanic and Atmospheric Administration and operated by the National Undersea Research Center at the University of North Carolina at Wilmington. In April, a team of astronauts will descend to the undersea laboratory for 18 days to hash out how man and machine can work together in extreme environments and to test a slew of robotic tasks, from low-gravity construction to remote-controlled surgery. "We'll have three or four types of rovers and other robotic apparatus, in addition to the surgical robots," says U.S. Air Force Lieutenant Colonel Ron Garan, an astronaut scheduled to submerge in April.

Garan's mission will be the ninth for NASA's Extreme Environment Mission Operations (nicknamed NEEMO in a nod to Jules Verne's submarine captain). The underwater effort is directed toward NASA's plan to return to the moon, and the three-second communications delay, or "latency," between Earth and moon will be factored into the experiments.

The environment outside the module is akin to the lunar surface, with one-sixth Earth's gravity. "Except for the view and the gravity inside the module, the environment is very close [to the moon's]," Garan says. "If something goes wrong, because of decompression, we can't just surface." Decompression in Aquarius requires a reduction of interior pressure over 17 hours, until surface pressure is reached. The crew then moves to the entry lock, is quickly recompressed to ambient water pressure, and is escorted up by divers.

Mehran Anvari, director of the McMaster University

NASA

In the Florida Keys, Doug Wheelock tries his gymnastic skills on the underwater lab Aquarius.

Center for Minimal Access Surgery at St. Joseph's Healthcare in Ontario, will take control of robotic arms on Aquarius to perform simulated operations on a high-fidelity model of an abdomen. Anvari will also talk the aquanauts through a diagnosis of a knee injury and the subsequent arthroscopic surgery—a skill that's wholly unknown to Garan, a former F-16 pilot. "It seems like non-physicians do a little better" than medical personnel doing tele-surgery, he noted. "They just do what the doctors say, like little robots."

Perhaps the greatest symbol of the growing symbiotic relationship between human and robotic explorers is a mockup of a communications tower the NEEMO team hopes to build on the sea floor. In reality, such a tower could extend more than fourfold the range of line-of-sight communications between explorers and their lunar base.

The astronauts will assemble the structure, made of PVC pipes, aided by swimming and crawling robots that will hold parts in place, fetch tools, and monitor the construction with cameras channeling images to command center monitors in Houston and within Aquarius.

Garan says the environment confers a personal benefit to aspiring astronauts by invoking the psychological reaction that no amount of training can fully anticipate. "It's a tight, confined space in a harsh environment, with an intensive schedule and little rest or relaxation, and you can't just come outside and go home," says Garan, who has not yet been to space. "To some extent I'll feel like I've been there, done that."

—Joe Pappalardo

Lunar Lots, Zoned Commercial

There's little doubt who owns the moonrocks, the 842 pounds of lunar material brought back by Apollo astronauts. NASA calls them "a priceless national and scientific resource," locks them in a vault, and prosecutes anyone caught trying to sneak away with as much as moon dust. The agency has traded a little of its treasure with Russia and turned a tiny bit into gifts, but makes it clear that every grain still belongs to the U.S. government. Now NASA's effort to return astronauts to the moon—this time to stay—has entrepreneurs eyeing lunar real estate.

BIRTHDAYS

Party Like It's 1935

December 17 marked the 70th anniversary of the first flight of a Douglas DC-3, which took place at Clover Field in Santa Monica, California, home of the Douglas Aircraft Company. To commemorate the blessed event, the National Aviation Hall of Fame and the Santa Monica Museum of Flying loosed a flock of -3s over Santa Monica Airport.

MIKE ULLERY

All in the family: The Douglas family and friends gather 'round a cheery Douglas DC-3.

The DC-3 revolutionized air travel, enabling the fledgling airline industry to carry passengers at a profit. The Douglas factory was torn down in 1975, and as Clover Field evolved into Santa Monica airport, little remained to mark the significance of the site. The Museum of Flying is donating a DC-3, *Spirit of Santa Monica*, to serve as the centerpiece of DC-3 Monument Park, the groundbreaking for which took place as the old airliners groaned and creaked overhead.

Last October at the National Academy of Sciences, James Dunstan, one of the few practicing space lawyers in the United States, and Klaus Heiss, leader of a settlement movement called Jamestown on the Moon, added their voices to a growing chorus urging the establishment of some sort of legal framework for staking claims on the lunar surface. Neither man pays much attention to speculators such as Dennis Hope, who claims that he alone owns the moon and has made a fortune in the past 25 years selling it off for less than $20 an acre. "The fact is, there are no property rights in outer space," says Dunstan.

NASA's unchallenged claim on the moonrocks has established that it's okay to own pieces of space. It's possible to own places in space, as Dunstan demonstrated in the 1990s when Holland-based MirCorp hired him to negotiate a contract to operate Russia's space station Mir commercially. The Washington, D.C. attorney used an apartment lease.

Unlike Mir, Dunstan argues, the moon is "untouchable." The Outer Space Treaty, approved by almost 100 nations, prohibits claims of sovereignty over celestial bodies. The Moon Treaty, signed by only a handful of nations—and not the United States—declares the moon and its natural resources the common heritage of mankind. Simply put, the moon is no man's land and every man's land.

"Forget the Outer Space Treaty," says Heiss, an Austrian-born economist who also happens to run High Frontier, a think tank behind the U.S. Strategic Defense Initiative in the 1980s. "Property rights will ultimately be the gateway to self-sustaining space activities," he says. "What is needed is to create the law." Heiss wants humans to settle the moon in much the same way American pioneers homesteaded 270 million acres of once-public land in 30 states between 1862 and 1986: with a little cash and a lot of hard work.

To Heiss, the "magnificent desolation" that Apollo 11's Buzz Aldrin described is a potential industrial park. Possible scientific and technical gains can be made in the fields of astronomy, communications, mining, power generation, and propulsion research. The moon has abundant solar energy, platinum-group metals, and volatile compounds. The Pentagon-supported Clementine probe and others have discovered evidence that the poles of the moon harbor enough water ice to make them "the most valuable real estate in the solar system" in the next 100 years, according to Heiss.

He's eager to create a futures market for business opportunities on the moon. "If we succeed in defining the rules on how to do it," he says, "I assure you this will be the hottest bidding process you have ever seen."

Dunstan is all for property rights, but he doesn't condone a U.S.-centered point of view. "I've always advocated to work

within the constraints of the international legal community as it now exists," he says. "Some say what we ought to do is pass domestic legislation establishing property rights. That would be a huge mistake because now you've put a target on your back for the rest of the world."

Dunstan suggests it might be enough to extend the United Nations registration convention for objects in space to objects on the lunar surface. Anything from a robot probe to a moonbase could be listed with the International Telecommunications Union by its lunar longitude and latitude, just as satellites are listed by their orbital coordinates.

The two men may disagree on method, but they're of the same mind on one point: If there's no way to protect private investment in space, then private investment will go somewhere else. Society's challenge, says Dunstan, is to make sure there's a place for the private sector in the lunar economy.

—Beth Dickey

"Trapdoor–Computer on Your Six!"

Frank Ferrante, call sign Trapdoor, estimates he's logged a few hundred carrier landings in his F-14 Tomcat, flying with his squadron, the Jolly Rogers. When he and fellow fighter jocks One Eye, Quiet, Cowboy, and Logs aren't in combat, they practice Blue Angels-style formation aerobatics. "Formation is one of the tougher things to do," he says in the typical fighter pilot's clipped diction. "Once you get behind an enemy fighter, it's hard to shake you if you're good at formation flying."

Sound observation, coming from a copy machine repairman. Trapdoor is not really a pilot. Neither is One Eye, Quiet, Cowboy, or Logs. "It's a little beyond my financial means," Ferrante says. "Plus I'm diabetic, so I'm not sure I could pass the physical anyway." He's a customer of Flightline Flight Simulation Center in Irvine, California, which offers full-cockpit flight simulators. All a fighter jock wannabe needs is $40.

The most realistic simulators are used to train commercial pilots in emergency procedures that would be too expensive or too dangerous to simulate in a real airliner. To take advantage of the explosion in computer gaming, Flightline has built a business around offering flight simulation to the public. The company has five cockpits, which its computer can program to fly like anything from an F-4 Phantom to an F/A-18 Hornet. The computer networks the five aircraft to simulate flying missions together against an enemy, or against one another. These aren't the full-motion simulators that mimic a real airliner, but you wouldn't know it from the way the civilian fighter jocks react.

"We have a night-vision camera pointed at the pilot's face, and when they make a hard turn their whole body moves," says George Schafman, director of flight operations and owner of Flightline. "The pilots are literally flying G forces that are not sustainable. Plus, they get the benefit of no motion sickness."

Some players have grown so enthralled by dogfighting that they've formed simulator clubs. "A good analogy would be a bowling league," Schafman says. "They're dedicated hardcore simulation players." Each squadron, named after real ones, like the Pukin' Dogs, the Tomcatters, and, of course, the Jolly Rogers, meets an evening or two each month, and gets three simulator hours for a price break.

"Everybody gets in a gung-ho mode," Ferrante says. "They wear flightsuits with patches because it's fun. With all the proper equipment you look the part. One guy even had a G-suit with the fireproof Nomex gloves. Not like we have to worry about fire protection."

—Phil Scott

MISSION ACCOMPLISHED

GUSTAVO CABANA

Red Sails in the Sunset

A team of skydivers set a record for Canopy Formation over Lake Wales, Florida, last November. After a week of practice jumps and training exercises, the group exited two CASA 212s and two de Havilland DHC-6 Twin Otters at up to 18,000 feet. The formation known as assembled on November 25, was made up of 81 jumpers; the next morning, the group achieved a formation of 86. The previous Canopy Formation record, 70, was set in 2003.

The formations are built by flying each parachute canopy carefully to a docking position on a jumper already in the formation," says participant Kevin R. Keenan, "and having that jumper hold on to the canopy by wrapping a parachute line around a foot." The group is planning its next record attempt—a formation of 100—for 2007.

Sweet Success

At first glance, SpaceShipOne seems out of place in the National Air and Space Museum's Milestones of Flight gallery. Hanging from the same ceiling as Bell Aircraft's beefy little X-1 and North American's hulking black X-15, SpaceShipOne looks almost like a toy, with blue and white stars sprinkled across the underside of the fuselage. Many of the artifacts in Milestones bear U.S. Air Force and NASA markings; SpaceShipOne, however, advertises itself as "A Paul G. Allen Project." On June 21, 2004, this "project," bankrolled by Microsoft co-founder Allen and designed by Burt Rutan, became the first privately built and piloted vehicle to reach space.

One reward for SpaceShipOne's achievement was an invitation by Museum curators to Allen, asking him to donate the spacecraft. Last October 5, Allen came to town to officially hand over the vehicle during a noon ceremony attended by dozens of reporters and thousands of Museum visitors. Rutan was also present, and during remarks by Allen, Rutan turned several times and looked fondly at SpaceShipOne, which was hanging behind the stage on which he stood. Earlier in the day, during a closed session with reporters, Rutan had confided: "It's a phenomenally warm feeling that goes through me when I see our ship in Milestones of Flight."

Rutan has every reason to be proud: He and the small team of designers at his Mojave, California-based company, Scaled Composites, sent a person into suborbital space on their first attempt. During the 24-minute flight last June 21, test pilot Mike Melvill took SpaceShipOne to an altitude of just past 62 miles. On September 29 and October 4, SpaceShipOne, fueled by solid and liquid propellants, again ascended into space, and these two flights earned it the $10 million Ansari X-Prize (see "Confessions of a Spaceship Pilot," June/July 2005).

SpaceShipOne designer Burt Rutan checked out an interactive kiosk that enables visitors to view footage of the spacecraft in flight and hear from the test pilots who flew it.

ERIC LONG (2)

As Paul Allen spoke at the dedication, presided over by Museum director John Dailey (center), Rutan couldn't help marveling at his creation's new home.

When Allen first thought of getting into the space business, everyone told him he should talk to Rutan. "So I went down to Mojave, and Burt started scribbling rapidly on napkins," said Allen.

Impressed by Rutan's vision,

VISITOR INFORMATION

February 11 & 25 Family Day: African-American Pioneers in Aviation. Meet members of the Tuskegee Airmen and listen to the music that was popular when they flew in World War II. Learn how their perseverance led to African-American training programs, flying clubs, and a network of sponsors. Enjoy hands-on activities and storytime for children ages four to seven and their adult companions. Museum on the Mall, 10 a.m. to 3 p.m.

Allen ended up contributing $25 million to cover the cost of developing SpaceShipOne. Rutan has had a prolific career in aircraft design (four of his airplanes are also in the Museum's collection), but the idea of designing a reusable manned spacecraft had him worried about "wasting Mr. Allen's money." The project took about a year longer than Rutan had anticipated, and foremost among his concerns was safety. Rutan was at Edwards Air Force Base in California in 1967 when Air Force test pilot Michael Adams was killed during his seventh test flight of the X-15. During the ascent to space, the rocket-powered X-15 experienced an electrical problem that left Adams unable to control the vehicle. The ensuing crash made clear to Rutan just how dangerous manned spaceflight could be.

Allen too was worried; his involvement in SpaceShipOne was the first time he had invested in a project that put human life at risk. "Your heart is in your throat," he recalled of being in the Scaled Composites control room during the first flight. The craft flew as expected and had no trouble reentering the atmosphere. Typical of many Rutan designs, SpaceShipOne is an all-composite vehicle, including its landing gear. Besides making the craft a relatively light 6,380 pounds, the use of composites eliminates the need for interfaces with metal parts.

After winning the X-Prize, Rutan had planned on continuing test flights in SpaceShipOne, and since the 28-foot-long spacecraft is a three-seater, he wanted to ride into space as a passenger; he also wanted to give Allen the opportunity to do so. "But the invitation from the Smithsonian prevented that," said Rutan. And SpaceShipOne had served its purpose. "We realized that we had learned all that we needed to on the technological issues," said Rutan. "So let's move on to a commercial space system. Start flying the public. Let them see that beautiful black sky.

"We are indeed in development on a large commercial system," said Rutan, but he would not reveal any research and development or flight-testing schedules. He did say that SpaceShipOne's successor, SpaceShipTwo, will have at least eight seats and that the craft will make plenty of test flights on its way to certification for ticket-paying passenger flights, giving Rutan, his test pilot brother Dick, Paul Allen, and journalists plenty of opportunities to fly into space. "A guy from CNN has been bugging me real hard," said Rutan, smiling.

SpaceShipTwo, which is being designed by Scaled Composites, will combine the experiences of a SpaceShipOne hop and a supersonic Concorde flight, taking its riders out over the Pacific. If the new craft is certified as a commercial vehicle, it will be manufactured, along with launch aircraft and support equipment, by the Spaceship Company, a joint venture between Rutan and British entrepreneur Richard Branson. Suborbital flights will initially be affordable only to the very rich, but Rutan predicted that ticket prices would be "low cost" after the first five or 10 years of operation (see "Go Ballistic," p. 20). "I won't be involved at all in the spacelines, just designing the aircraft," he said. If Rutan's past career is any indication, SpaceShipOne won't be his last Museum piece.

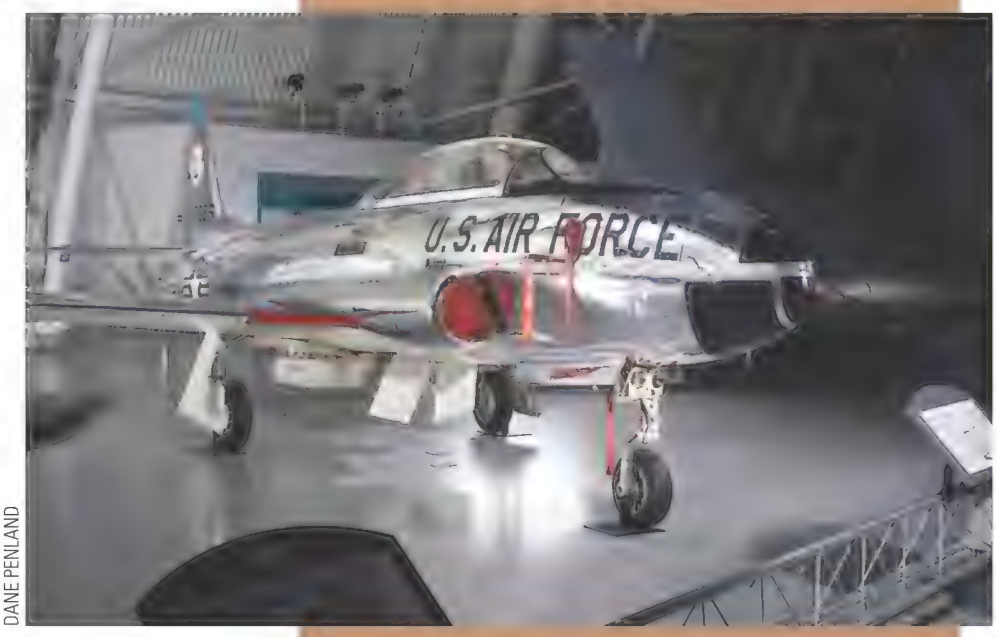
—Diane Tedeschi

ARTIFACTS

Shiny Shooting Star

The Lockheed T-33A Shooting Star entered the U.S. Air Force inventory as a jet trainer in 1948, and by 1958, Lockheed had manufactured 5,691. The T-33 was also widely used in Latin America and southeast Asia, and in the 1950s, Canada and Japan started building T-33s for export to Europe and South America. After a run of more than 30 years, the Air Force started retiring Shooting Stars in the 1980s.

On September 25, 1954, nine days after it came off the assembly line at Lockheed's Aircraft Factory B-4 in Palmdale, California, the Museum's T-33A, serial number 53-5226N, was delivered to Air National Guard Headquarters at Andrews Air Force Base in Maryland, where it remained until it was transferred to the Museum on October 30, 1987.



DANE PENLAND

The highly polished aluminum skin of the Museum's Lockheed T-33A has never been painted.

March 18 Kite Day. Make your own kite, learn how kites fly by watching indoor kite-flying demonstrations, view a collection of historic kites, and speak with local kite experts. Museum on the Mall, 10 a.m. to 3 p.m.

March 25 Women in Aviation Day. Celebrate Women's History Month by viewing science projects completed by local Girl Scout troops, participating in hands-on educational activities, and talking with Museum staff about the contributions of women to science and aviation. Steven F. Udvar-Hazy Center, 10 a.m. to 3 p.m.

Curator's Choice
Occasionally a National Air and Space Museum curator gives a 15-minute talk about an artifact or subject of interest at either the National Air and Space Museum on the Mall or the Steven F. Udvar-Hazy Center in northern Virginia. In the Museum on the Mall, meet at noon at the gold seal near the Information Desk; in the Steven F. Udvar-Hazy Center, at the nose of the SR-71 Blackbird reconnaissance aircraft.

Museum on the Mall: Feb. 15, George Carruthers' Telescope; Feb. 22, Cornelius R. Coffey and African-American Flight Training; Mar. 1, Women's Work in Astronomy; Mar. 8, Valentina Tereshkova—First Woman in Space.

Udvar-Hazy Center: Feb. 2, Space Shuttle Radar Topography Mission—Mapping the Earth in the Global Age; Feb. 16, Arlington Sisu 1A—First Sailplane to Fly 1,000 Kilometers; Mar. 2, Pegasus XL Launch Vehicle; Mar. 16, Airships.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.si.edu *or call Smithsonian Information at (202) 357-2700; TTY: (202) 357-1729.*

Collision Course

COURTESY C.L. KOELZER

Post-flight, the computer zoomed in on the graphic display of the two aircraft in a hair-raising image.

"Shooter five-five, flow zero nine zero." My flight leader, call sign "Shooter 55," has ordered our egress, or "flow," headed east. With both throttles on my F/A-18 locked in maximum afterburner, I'm light in my seat as I push the stick forward, descending and accelerating rapidly through 460 mph. I twist on my ejection seat, grabbing the hand-holds welded to the canopy bow, straining to look aft for adversary aircraft rolling in on my tail—the infamous six o'clock position from which most shootdowns occur.

It's 2002, we're flying over the southwest desert, and we've just had a dogfight with two aggressor F-5Es from Marine Fighter Training Squadron 401. Luckily, both bandits are dead, and now we're continuing our mission—a fighter sweep to clear the area of enemy aircraft. I'm Shooter 56, and in my jet's rear cockpit sits a student weapons and sensors officer (WSO), who is supposed to be clearing our six as we exit the fight. I can see his shiny white helmet in my rear-view mirrors, but instead of looking aft, it's pointed downward, at his lap, and all I hear from the back seat on the intercom is *Blaaahhhckk! Blaaahhhckk!*

Two miles off my left wing, the pilot in Shooter 55 is Twitch, a friend of mine, and as instructors in Marine Fighter Attack Training Squadron 101, it is our enviable duty to teach young pilots and WSOs the finer points of fighter flying/riding. Sometimes it's so fun they puke.

Like today. My WSO is worthless to me now, and I can only hope there aren't little globules of his lunch floating around the cockpit under zero G. I check our six—it's clear—so I decrease the dive angle, reset my radar to search mode, and get a visual sighting on my flight leader. "Shooter five-six visual, right two o'clock, two miles, a little high."

"Visual," says Twitch.

The radios, feverish only moments before from a raging two-versus-two dogfight, settle into uncomfortable silence. My intercom, however, crackles *Blaaahhhckk!*

A small green rectangle appears on the blank square of my radar display. "Shooter five-six, snap two o'clock, eight miles, 22,000, hot," I call, with target data in bearing-range-altitude-aspect format. It's an untargeted bogey (not yet identified), and since it's too close for us to run away, we're committed to a head-to-head altercation in the sky, known as a merge.

"Shooter five-five…clean." Because the bogey is above our altitude, the contact is in Shooter 55's assigned search sector, and Twitch's student WSO has failed to get their radar on the unknown aircraft (their radar display is empty, or "clean").

So far, things aren't going so hot. We have a short-range unidentified target that my flight leader can't find, and my WSO has his nose wedged in a sick sack. I'd love to just squeeze the trigger and send a simulated missile on its way to end this problem, but I can't shoot without a positive identification. Instead, I roll right and yank the stick back, wrapping the F/A-18 into a 6-G turn to get my nose on the bogey. Peering into my head-up display, I see a small speck framed in a green target designator box, three miles away, coming downhill and closing fast. "Shooter five-six, tally one, on the nose, three miles, five degrees high."

"Shooter five-five, no joy, visual." Twitch and his WSO don't see the bogey ("no joy") but still have sight of my jet ("visual").

The dot in my HUD closes rapidly, slightly right of my nose and a little high. I count down the seconds until our merge, so that when I visually identify the bogey, Twitch will finally see it and take a quick shot. "Three…two…one…" I see that it's an F-5E, with blue and gray mottled camouflage, as it flashes by my right side in a right-to-right merge… "Shoot, shoot, F-five!"

"No shot—no joy—visual," calls Twitch, unable to spot our adversary's blue jet against the blue sky.

I pull back hard at the merge, grunt against the Gs, and crank the Hornet into a climbing right-hand turn. With my left

fist gripping the canopy bow's right hand-hold, I again twist to look aft, barely keeping sight of the F-5E turning nose-low across my tail, also in a right turn. Airspeed bleeds rapidly from the climbing Hornet, and I ease the stick farther back to get the nose around. "Engaged two-circle right turns, nose-high to the west," I call.

"Three miles northeast, visual, no joy." Twitch still sees me, but not the F-5E. He's now just a high-speed cheerleader.

And I'm in a one-versus-one. Crunching my abdominal muscles to help me look over my right shoulder, I still see the bandit F-5E below the horizon on the opposite side of my turn circle. Brown desert quickly replaces blue sky in my partially inverted canopy, and halfway through the turn a sharp yank on the stick honks the nose out of the vertical and points it at my opponent. The radar's air combat maneuvering mode locks the F-5E at a range of two miles, and I select an AIM-120 radar-guided missile with the switch under my right thumb. A quick pull of the trigger launches a simulated weapon, and I call "Fox three" on my flight's radio frequency to announce the shot.

I shove the stick forward to break the high-angle-of-attack turn, decrease the drag, and get some airspeed back. The F-5E's nose is pointing slightly right of me now, and it looks like we're going to meet in another right-to-right merge as the digital time-to-impact counter in my HUD reaches 0. I'm about to key the mic and call the bandit dead when I suddenly notice that something is dangerously wrong. I expect to see the F-5E pointed almost directly at me, cooperatively maneuvering to another merge with safe flight path separation. But instead of his nose, I'm looking at his belly.

He's turning in front of me—less than a mile away. We call it CBDR, for constant bearing, decreasing range, and it means our flight paths will soon co-exist in both time and space. By the time I can make a warning call on the radio, I'll be dead.

PUSH! I shove the stick forward, thinking I can dodge underneath him. But at less than 230 mph, even the Hornet's huge horizontal elevators can't pitch the nose down as fast as I need to move it. The F-5E is still in a right-hand turn, and its belly looms in my windscreen.

PULL! Try something new. I wrench the stick into my lap to try to climb above the 13,000-pound arrowhead winging at my soft pink body. Not working. I'm so slow that the nose of my Hornet is moving, but my flight path vector is not, and the teeny F-5E looks bigger than a space shuttle. Absolutely unavoidable.

PUSH! Back to Plan A. My right hand again shoves the stick hard, almost to the instrument panel, and I float in my ejection seat, restrained only by the four harness straps. The light blue belly of the F-5E fills my windscreen, and my mind takes a mental snapshot that I will never forget. An orange instrumentation pod occupies the tip rail of the F-5E's right wing, seemingly inches from my nose, and a captive Sidewinder training missile sits on the left wingtip.

The entire push-pull-push process takes barely a second, and feels like much less, with no chance to panic or yell or watch my life flash before my wide-open eyes. Nonetheless, it's enough time to be gripped by frustration and utter disgust—that I had put myself in this predicament, that I know I am about to collide with another fighter on a training mission, that I probably am about to die. Yet there is also a split-second of hope—that somehow we'll survive the ripping metal and streaming, fuel-fed fireball, that we'll only *barely* hit, that we'll make safe ejections…

WHOOOOOOOSH! The humongous F-5E blocking the sky suddenly disappears. I don't even see it whip past, though it must have—but it felt as if the jet passed *through* us. In the span of a nanosecond, our atoms met, fused, and separated, while a quick thunderclap of jet noise crescendoed. It takes another second or two for the far-too-loud sound of the F-5E's diminutive J85 afterburners to register in my saturated mind, with the abrupt realization that I am in open airspace—nothing but blue between me and Mexico. I am still alive, and not fluttering through the thin air of high altitude as a million bits of ash.

"Knock it off, knock it off." It was the F-5E pilot. A pause, then: "Did we just have a close pass?"

"We *did* just have a *very* close pass," I reply, with the artificial calm of abject disbelief as I look over my jet. Expecting to see a missing tail or wingtip at the very least, I am stunned—and immeasurably thankful—that my lovely Hornet is intact.

Our fuel is low, and so is my motivation to fling myself at another F-5E, so we head home. "Did you see that?" I ask the student WSO. I haven't heard a peep from him since before the first merge, and I hope he's still conscious.

"See what?" Conscious, and oblivious.

I knew it had been close, and back in the debrief at Marine Corps Air Station Yuma, I was about to learn just *how* close. The instrumented pods carried by both jets measured aircraft separation based on Global Positioning System data, and the computer display read nine feet. Nine feet, plus or minus three. With 45,000 pounds of aluminum, composites, fuel, and human beings mixing flight paths at 700 mph of closure, that's pretty darn close.

Even post-flight, I couldn't say for sure if the F-5E went above or below us. Neither could the computer, because when we zoomed in on the graphic display of our two aircraft, we saw a haunting image of a blue Hornet and a red F-5E, fused in mid-air. The first few words (following the four-letter exclamations) with the adversary pilot enlightened us all as to the cause of the near-miss. In air combat training, we're never supposed to get any closer than 500 feet to another aircraft, but after the first merge I had wrongly assumed the F-5E driver still saw me. While I was planning on meeting him in another right-to-right pass, he in fact had lost sight of me, but spotted Twitch (about two miles to the northeast) and was turning against him—and directly in front of me. I had broken a fundamental rule: Always assume everyone else does not see you. By assuming the opposite, I had almost killed three men.

As I mulled this over, a number-crunching computer tech gleefully informed me that, based on the instrumentation pods' location on the two aircraft, and relative aircraft position, the true miss distance was even closer. Actual miss distance: one foot, plus or minus three.

—C. L. Koelzer

WHOOOOOOOSH! The humongous F-5E blocking the sky suddenly disappears. I don't even see it whip past, though it must have—but it felt as if the jet passed through us.

DAVID CLARK

Pilot 1, Scientists 0

Biologists are enamored with flying. With an airplane, you can count, track, and photograph, get to remote places fast, and avoid mud and mosquitoes. Used to be what made a biologist was the ability to tolerate mud and mosquitoes. I wouldn't have been a biologist then.

The relationship between the scientist passenger and pilot is naturally strained. Catering to the deductive impulses and whims of scientists while flying an airplane is a tricky, sometimes miserable business: You don't have the absolute control you normally do, because scientists are always telling you where, and sometimes how, to fly, and the justification is always some blather about sample size, couched in some highfalutin pursuit-of-truth context. They're obsessive, tunnel-visioned freaks, and the pilot and airplane are just another microscope or particle accelerator. I know this because I've been both scientist and pilot, and both at the same time. As a scientist, I can be a very difficult passenger, and a while back I decided I would never be a pilot for scientist-me again. I kept telling me to do things I didn't want to do.

A year after the guy steering the *Exxon Valdez* had driven it onto Bligh Reef, I got a job in Alaska. The *Valdez* oil had killed, among many other things, a bunch of seabirds. As a reason to be in Alaska it was decidedly inferior, but when you're a graduate student you take what you can get. This time what I could get was the chance to radio-track a bunch of dead birds. The question raised by the thousands of dead birds recovered after the spill was: How many really died? To know that, we had to know what happens to birds after they die. This entailed chasing drifting carcasses around the Gulf of Alaska in a Grumman Goose.

Our pilot, Dave, was a lanky, laconic Western Man with a deep voice and grand moustache with drooping handlebars that he attended to at timely moments. Our first flight was to test some radio tracking equipment. On a glorious, calm day, we landed in Prince William Sound, dropped a transmitter buoy in the water, and took off to test our receivers. I was my usual difficult scientist self.

"We seem to have a lot of interference on the receivers," I announced over the intercom to my colleague, Mike, the other problem-child scientist on board. I listened some more. The frequency was familiar. "Sounds like magneto noise." I thought about those two beautiful 450-horsepower radials out on the wings and their 50-year-old-technology ignition harnesses. "I think the mags are bleeding into our receivers, Dave."

Mike wanted this to work and for us to get home. He'd spent thousands of hours in aircraft over oceans, surveying birds and whales. Some time ago, he'd spent one hour too many in a Cessna Skymaster with only one engine working. "Are you sure?" said Mike.

"Well, yeah, I think so." I didn't want to sound too sure, because then it would be apparent that I should have anticipated the problem. A couple of months before, I'd spent a lot of our small consulting firm's money to supervise the installation of the tracking equipment on the Goose.

Just as all humans—such as the scientists in the back seat of this airplane—want control, so are all humans first and fundamentally scientists. Pilot Dave had flown with professional ones long enough to see a splendid opportunity to avenge all the crap they'd put him through all these years. "Well, let's just see," he said.

His mischief translated even over the primitive intercom. Mike and I looked forward to see him, with the fluidity of the Phantom of the Opera at the big old organ, reach up and pull the throttles, carburetor heat, and mixtures and switch off four sets of magnetos—with just the opposite of the Phantom's effect. The silence was startling; I remember thinking: *Damn, it must have been noisy in here just a second ago. This is really nice.* I then shared with the rest of the intercom folks: "Yup, that was it."

Grumman made canoes that would probably glide farther than the Goose, and Mike, revisiting other unwanted descents toward water, acknowledged the elegance and efficacy of Dave's experiment right away. "Okay, Dave. Turn them back on."

"You're sure? That's not much of a *sample*." God, but it was fun to throw this stuff back at them, the prima donnas. The Goose continued its silent plummet.

"Yes, Dave. Thank you," Mike said.

More organ playing, and the big Pratts resumed their function, and their contamination of my receiver. His right hand free, Dave twirled both moustache handlebars, now slightly raised.

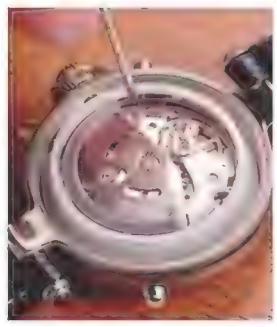
—Douglas R. Warrick

World's Most Valuable Timepiece Disappears

Back in 1933, the single most important watch ever built was engineered for a quiet millionaire collector named Henry Graves. It took over three years and the most advanced horological technique to create the multifunction masterpiece. This one-of-a-kind watch was to become the most coveted piece in the collection of the Museum of Time near Chicago. Recently this ultra-rare innovation was auctioned off for the record price of $11,030,000 by Sotheby's to a secretive anonymous collector. Now the watch is locked away in a private vault in an unknown location.

We believe that a classic like this should be available to true watch afficionados, so Stauer replicated the exact Graves design in the limited edition Graves '33.

The antique enameled face and Bruguet hands are true to the original. But the real beauty of this watch is on the inside. We replicated an extremely complicated automatic movement with 27 jewels and seven hands. There are over 210 individual parts that are assembled entirely by hand and then tested for over 15 days on Swiss calibrators to insure accuracy. The watches are then reinspected in the United States upon their arrival.



27 jewels and 210 hand-assembled parts drive this classic masterpiece.

What makes rare watches rare?

Business Week states it best…"It's the complications that can have the biggest impact on price." (*Business Week, July, 2003*). The four interior complications on our Graves™ watch display the month, day, date and the 24 hour clock graphically depicts the sun and the moon. The innovative engine for this timepiece is powered by the movement of the body as the automatic rotor winds the mainspring. It never needs batteries and never needs to be manually wound. The precision crafted gears are "lubricated" by 27 rubies that give the hands a smooth sweeping movement. And the watch is tough enough to stay water resistant to 5 atmospheres. The movement is covered by a 2-year warranty.

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GO BALLIST

by Craig Mellow

The price of a ride into space is astronomical, but so is the view.

COURTESY SPACE ADVENTURES

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ANYONE THINKING OF becoming a pioneering space tourist and forking over $200,000 for five minutes in the cosmos come 2008 or so might want to delay the travel plans. To judge by a recent showcase dubbed "Countdown to the X PRIZE Cup," held in the high desert of southern New Mexico, your chariot does not exactly await.

Of eight blastoffs and test ignitions meant to wow 13,000 onlookers at Las Cruces airport, near the White Sands missile range, all but two were scrubbed. The first test system, a squat rocket from Texas-based Armadillo Aerospace, remained airborne for maybe eight seconds, returned to Earth with a thud, and fell over onto its side. The fall caused a leak in the fuel lines, forcing cancellation of two more launches that had been promised by Armadillo CEO John Carmack, an endearing motor-mouthed geek in khaki shorts who is funding his space adventure from the fortune he made designing the Doom series of computer games.

The Countdown's all-day-awaited finale, the test-firing of a kerosene-propelled, 15-ton-thrust engine by Starchaser Industries of Manchester, England, ended in an inferno that blew the engine to bits. A voice of restrained alarm announced over the scratchy two-way radios: "Emergency—we have an emergency situation on the field"—and sinister-looking black smoke wafted for miles out toward the Organ Mountains.

X-Prize Foundation Chairman Peter Diamandis was unperturbed. "Wasn't that great?" he cried, descending on the press tent as puzzled reporters were interviewing each other, trying to piece together details of the blink-and-you-missed-it Armadillo flight. "Next year we're going to have two of them racing straight up side by side."

In fact, Diamandis has earned the right to some enthusiasm. If last year's X-Prize victory enshrined Burt Rutan's SpaceShipOne as the Wright *Flyer* of the personal-spaceflight revolution, Diamandis is emerging as the movement's P.T. Barnum. A diminutive 43-year-old given to flashier jewelry and a bossier demeanor than the average guy with an M.D. from Harvard and an engineering degree from MIT, Diamandis established the X-Prize in 1995, later convincing Iranian-American telecommunications entrepreneur Anousheh Ansari to put up $10 million for the winner. While pushing hard to turn the X-competition into an annual event that "families will plan their vacations around," he is also a lead investor in the two most visible space tourism businesses: Space Adventures, which last autumn took its third

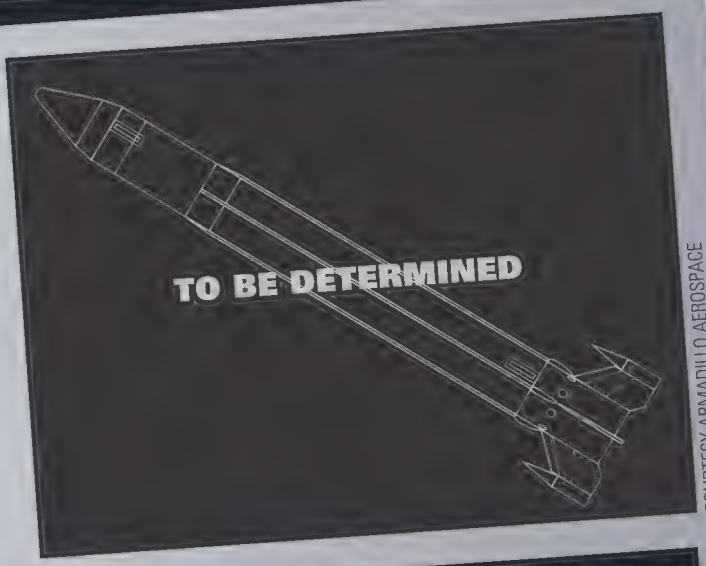
COURTESY STARCHASER INDUSTRIES

COMPANY NAME
Starchaser Industries, Manchester, England
LOCATION
VEHICLE
THUNDERSTAR
PRICE
$429,931 (£250,000)
NUMBER OF PASSENGERS
Three
TENTATIVE LAUNCH DATE
October 2006
LAUNCH LOCATION
Las Cruces, NM

COURTESY AERASPACE TOURS

COMPANY NAME	Sprague Astronautics,
LOCATION	San Diego, CA
VEHICLE	ALTAIRIS ROCKET
PRICE	$250,000 in 2006; $150,000 in 2007
NUMBER OF PASSENGERS	Seven
TENTATIVE LAUNCH DATE	December 2006
LAUNCH LOCATION	Cape Canaveral, FL

COMPANY NAME	Armadillo Aerospace
LOCATION	Mesquite, TX
VEHICLE	Unnamed
PRICE	$100,000 to $200,000
NUMBER OF PASSENGERS	One
TENTATIVE LAUNCH DATE	No date set.
LAUNCH LOCATION	Southwestern Regional Spaceport, Las Cruces, NM



COURTESY ARMADILLO AEROSPACE

COURTESY INTERORBITAL SYSTEMS/ASTRO EXPEDITIONS

COMPANY NAME	Interorbital Systems/Astro Expeditions
LOCATION	Mojave, CA
VEHICLE	NEPTUNE SAANTO SPACELINE (for orbital flights)
NUMBER OF PASSENGERS	Five
PRICE	10 promotional fares at $250,000 (two have been sold); full fare at $2 million.
TENTATIVE LAUNCH DATE	Late 2008
LAUNCH LOCATION	Floating launch from the Pacific, 200 miles off Long Beach, CA. Future flights from various ocean sites, including near Tonga.

$20 million passenger to the International Space Station, and Zero Gravity Corporation, purveyor of the "vomit comet," a ballistic Boeing 727 that simulates spaceflight for its passengers by treating them to moments of weightlessness for $3,750 a head.

Diamandis was in an ecstasy of activity at Las Cruces, alternately terrorizing a young aide to New Mexico Governor Bill Richardson over a detail of logistics and jumping on photo-ops with visiting dignitaries like Steve Robinson, the astronaut lately returned to Earth after walking in space to remove stray fibers from *Discovery*'s heat shield. Diamandis' X-rhetoric is inflammatory in a carefully calculated way. "What the government is doing in space is like IBM of the 1950s," Diamandis said. "These guys," he waved at the space tinkerers fitting valves and stenciling logos all around him, "are the Apple Mac. They're the rocket equivalent of playing Pong on an Atari. They are going to blow by the Lockheeds and the Boeings because the military industrial complex is stuck in its paradigm."

That sort of talk evidently appeals to a growing number of tycoons who made it big a generation ago by being inventive, outlandish, or lucky. Sir Richard Branson lit the afterburners of the new space race in September 2004, announcing he would stake Rutan to $100 million to build SpaceShipTwo, a winged vehicle comfortable and flight-tested enough to give seven super-platinum customers their whiff of weightlessness aboard Virgin Galactic starlines. (Microsoft co-founder Paul Allen financed SpaceShipOne with $25 million.) Elon Musk, founder of the PayPal e-payment system, is much more quietly backing SpaceX Corporation, which is building some new cargo launchers called Falcons. *Amazon.com* megapreneur Jeff Bezos is bankrolling Blue Origin. No one knows anything about what they are doing, except that they have the cash to do it.

This trickle of capital has lured from the woodwork a gleefully self-described band of pyromaniacs, overage Trekkies, and former juvenile backyard destroyers addicted to space but too rambunctious to hold desk jobs at NASA. Geoff Sheerin, head of Ontario-based Canadian Arrow, which aims to take passengers beyond the stratosphere aboard a modified version of Nazi Germany's V-2, spent his leisure

time through much of the 1990s skulking around archives at the V-2's birthplace in Peenemünde, finally laying hands on a buried cache of original technical documents. "I thought life had passed me by until X-Prize came along," he says. "The prize gave me my first ounce of credibility." Starchaser boss Steve Bennett quit his job as a chemist in 1992, no longer able to bear the frustration of being prohibited from producing explosions. An appealing bunch of characters to be sure, but would you trust your life to them?

LISTEN FOR 10 SECONDS or so to any spaceflight revolutionary and you will hear the Big Vision, a vague but impassioned rendering of mankind's multiplanetary future that makes liberal use of analogies to Columbus, the California gold rush, Lindbergh, and other ultimately lucrative leaps into the unknown. "There will definitely be population centers beyond the Earth by the end of this century—space miners, space hotel keepers," says Esther Dyson, the New York publisher and venture capitalist whose *Release 1.0* newsletter took the pulse of the Silicon Valley revolution and who is now an investor in Space Adventures.

Jeff Greason, CEO of Mojave-based rocket builder XCOR, offers a prediction more concrete but, in its view of human progress, perhaps bleaker. "By the time NASA gets astronauts to Mars, McDonald's will be there waiting for them," he quips. Peter Diamandis is, of course, extravagant: "The greatest wealth ever known will be made when we open the space frontier—from its resources, real estate, transportation. The first trillionaires will come from space."

But to earn the first few nickels on the way to those trillions, the space community is coalescing around entertaining mere millionaires yearning for a suborbital experience. This is a rocket-propelled journey that carves a sharp parabola peaking at an altitude of about 100 kilometers (62 miles), the so-called Karman line, accepted by the Fédération Aéronautique Internationale as the atmosphere's outer limit. From this height, passengers can drink in the epic view of Earth that has so far been limited to government-sanctioned astronauts, and experience microgravity—for the four to five minutes, anyway, that their vehicle takes to come over the top of its arc and hurtle back into Earth's gravitational field.

COURTESY ROCKETPLANE LIMITED

Unlike orbital rockets, which accelerate to Mach 25, the parabolic trajectory will require only a fraction of that velocity, no more than three to four times the speed of sound. People of average health and fitness can experience a brush with the infinite. "It's amazing how out of shape you can be" and still qualify for spaceflight, says Andrew Case, a former University of Maryland physicist who now heads a fledgling trade organization called the Suborbital Institute. "If you're healthy enough to do white-water rafting, you're healthy enough for spaceflight."

Average income is another matter entirely. When it unfurled the business, Virgin Galactic set the $200,000 benchmark—for a ride that, to be fair, will take about two hours altogether plus a week or two of "training" beforehand. Like almost everything else about space tourism, the number at this point is speculative and subject to hot debate. "The going number before Virgin came in was $100,000," snipes Chuck Lauer, director of business development for Rocketplane, a rival backed by Midwestern billboard entrepreneur George French and the state of Oklahoma. "But if Richard Branson wants to come put $100,000 extra in my pocket, I'll take it." Everyone's business plan, though, depends on "early adapters," the first consumers to buy a new technology. Early adapters don't worry about cost, keeping the industry going for a few years at least.

The second revolution-wide consensus—or depending on who is talking, point of pride—is that some of these highest-tax-bracket cosmoneers will get blown up and die a horrible death. Even the Federal Aviation Administration can barely curb its enthusiasm about its inability to guarantee space tourists' safety. "It was more than 20 years after the Wright brothers that the Civil Aeronautics Board was created, and I wonder whether the progress in aviation could have taken place if it had been regulated before that," reflects George Nield, deputy associate administrator for commercial space transportation, a post created six years ago to monitor commercial space ventures. "We are working on an informed-consent principle that recognizes space travel is inherently risky. That's what we do in this country. We allow people to take risks."

The only sour note, significantly, is sounded by someone who actually has risked his life in space: astronaut Steve Robinson. "It's really expensive to be safe, and when you're trying to make a profit, that's one area that you're going to look at to make cuts," he said,

surveying the mock-ups and scale models on display at Las Cruces. "Some of these companies seem to understand the engineering challenges involved in spaceflight, and some don't."

When it comes to how to deliver the suborbital experience, the unanimous industry machismo is happily replaced by a cacophony of competing designs and modi operandi: from the lean futurist lines of SpaceShipOne, beside a facsimile of which Virgin Galactic vice president Steven Attenborough makes a two-minute appearance with the air of a purebred among mutts, to the workhorse steel cylinder of Canadian Arrow's proudly reincarnated V-2.

Some rocketeers envision mid-air launches from carrier aircraft, like the White Knight that toted SpaceShipOne. Others are planning on launch pads at New Mexico's spaceport-to-be, for which the state has just committed $250 million and is concluding long-running negotiations with two old-line ranching families that had grazing leases on the site. Others prefer barges on the Great Lakes. The unofficial X-resourcefulness prize goes by general acclaim to the Toronto-based da Vinci project. Their ungainly cosmic prototype is slated to dangle until 70,000 feet under the harness of a yet-to-be-built world's biggest helium balloon, then fire its engines at that altitude. While competitors are paid by stargazing magnates from other fields, da Vinci has survived so far on less than $2 million and thousands of volunteer hours from patriotic Canadian engineers.

But the basic dichotomy in the nascent space tourism business comes down to airplane guys vs. rocket guys. (Few women have yet been drawn to the industry, save as PR operatives on a degeekifying mission.)

The suborbital rocket experience will be an express trip: 15

COURTESY BRISTOL SPACEPLANES

COMPANY NAME	Bristol Spaceplanes
LOCATION	Bristol, England
VEHICLE	ASCENDER
PRICE	$200,000
NUMBER OF PASSENGERS	Two
TENTATIVE LAUNCH DATE	No launch date set
LAUNCH LOCATION	Any suitable 7,000-foot runway

COMPANY NAME	PlanetSpace, London Ontario, Canada
LOCATION	
VEHICLE	CANADIAN ARROW
PRICE IN US DOLLARS	$250,000
NUMBER OF PASSENGER SEATS	Two, with later designs for up to seven.
TENTATIVE LAUNCH DATE	Date not firm
LAUNCH LOCATION	Launch site not set

COURTESY PLANETSPACE

COURTESY ORVA SPACE CORP., DA VINCI PROJECT (2)

Wild Fire MK VI rocket (above). Project Tiger spaceplane (right) will carry seven passengers.

COMPANY NAME	ORVA Space Corp, da Vinci project
LOCATION	Toronto, Ontario, Canada. Also known as GoldenPalace.com Space Program.
VEHICLE	WILD FIRE MK VI rocket Second generation: PROJECT TIGER
PRICE	$250,000 per passenger for the Wild Fire MK VI rocket, carrying two passengers
NUMBER OF PASSENGERS	$150,000 for the later Tiger spaceplane, holding seven passengers
TENTATIVE LAUNCH DATE	Late 2008
LAUNCH LOCATIONS	Wild Fire rocket, from Saskatchewan, Canada. Tentative launch runway for the Tiger is Southwestern Regional Spaceport, Las Cruces, NM

SpaceShipOne got the free-market-rocketry ball rolling.

ERIC LONG/NASM

minutes or so from liftoff to touchdown, but filled (would-be purveyors promise) with enough noise, adrenaline, and wonder to last a lifetime. "This way you'll feel what Alan Shepard or Gus Grissom felt," enthuses Starchaser's Steve Bennett. "You've got a spacesuit on, you're strapped in, these huge engines roaring under your back. This isn't some kind of flying tour bus."

Airplane men sniff at the idea that passengers would actually choose 15 minutes crammed into a hatch and a kidney-thumping vertical return to earth, compared to their suspense-building two-hour ascent to the heavens, Learjet-like interiors, and the ease of alighting on wheels rolling down a runway.

The surest sign that the personal spaceflight revolutionaries are onto something may come from their favorite whipping boy, NASA. In a telling exhibition of if-you-can't-lick-'em-join-'emism, Brant Sponberg, who manages a new NASA program to sponsor X-Prize–style derbies (see "Going Up?" p. 58) joined Diamandis on the Las Cruces airport ramp to announce two: a Suborbital Payload Challenge, which will demand a flight "much higher" than SpaceShipOne's 100 kilometers, and one for analog lunar landers.

This momentum for private space companies will not long escape the attention of restless venture capitalists, guesses Aneel Pandey, one more cashed-out dot-com'er who has recycled part of his gains into XCOR. "People in the investment community go through stages," he explains. "There was tech, then house-building. Eventually they will cycle into space exploration."

That doesn't mean, though, that anyone is close to ready with a reusable edge-of-space ship built to a commercial budget and offering the comfort and reliability expected by super A-list passengers. "There's not one big thing left to be done, there's a thousand little things," comments XCOR's Greason, who, Quarter Pounders on Mars aside, is one of the industry's more thoughtful figures. "Most of all we need flights. If you're going to say that your system fails less than one time in a thousand, you'd better have 1,000 flights under your belt."

Potential patrons view space travel as less risky than skydiving or mountain climbing, according to the most frequently cited marketing study in the field, conducted by Virginia-based consultant Futron Corp. While rocketeers from every faction cite the 2002 Futron study as proving potential profitability, the group's conclusions—based on surveying 450 Americans, each with a net worth in excess of $1 million—are in fact quite modest. Futron projected suborbital passenger volumes creeping up to 2,000 a year only six years after the first flights, which the group optimistically predicted would fly in 2006 and at a pre-Branson cost of $100,000. Those numbers might support two or three moderately profitable spacelines, but will hardly spin off the capital to ignite FAA booster Nield's vision of "hundreds of manufacturers producing thousands of aircraft."

And Futron did not even try to factor in the accident that everyone agrees is a certainty sooner or later, the neo-*Challenger* images of conflagration that will likely be the first serious attention most of the world pays to space tourism.

Peter Diamandis, a man not often left without a comment, says he knows exactly what he will say when the world press comes battering his door after the first fatalities. "I'll tell them that space is the greatest frontier standing before humanity," he intones. "That I'm thankful that thousands of people gave their lives to open the American West and other earlier frontiers. That if they don't want to take risks to be a part of this, they had better stay out of it."

But first, let's have a launch.

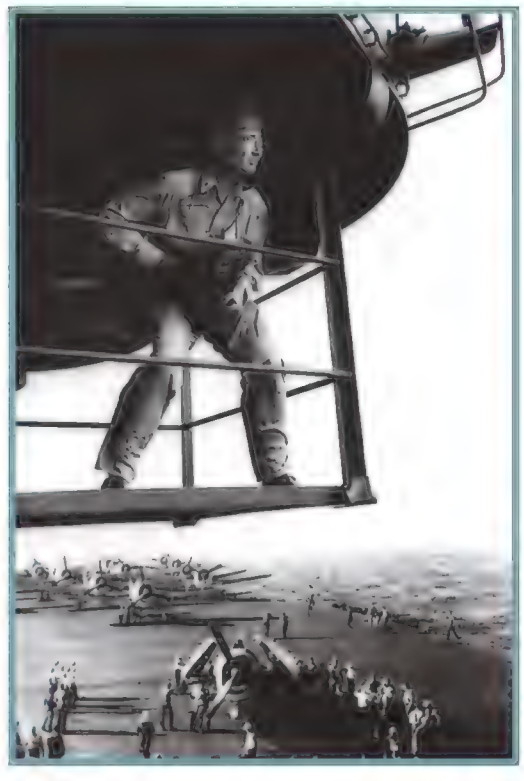
STEICHEN'S NAVY

ONE OF THE WORLD'S GREAT ARTISTS GOES TO WAR.

by T.A. Heppenheimer

Before Edward Steichen joined the U.S. Navy in January 1942, he had been chief photographer for Condé Nast magazines *Vogue* and *Vanity Fair*, a commercial photographer for the J. Walter Thompson Advertising Agency, a curator at the Museum of Modern Art in New York, and a painter exhibited in Paris salons. He was in his mid-60s when he went to war for the second time. During World War I, he had helped establish the first U.S. aerial reconnaissance operation, originally for the Army Signal Corps, later under the auspices of the American Expeditionary Forces Air Service. Traces of the fashion photographer, ad man, fine artist, and patriot show up in the photographs made by him and by the six photographers he recruited to document World War II naval operations.

In the first world war, Steichen had managed to get into the Army's photographic division, even though in 1917, at 38, he was eight years past the age limit for recruits. A U.S. citizen, he had been living in France when the war began, and, beyond his ambition to be a war photographer, he wanted to help resist German aggression. He was proud of his service; for years afterward, he listed himself in the New York telephone directory as "Steichen, Col. Edward J."



NAVAL HISTORICAL FOUNDATION

The master at work (right). His staff shot men and machines—here, a ship's crew watching a TBF hoisted aboard.

ALL PHOTOGRAPHS: NATIONAL ARCHIVES

IN OCTOBER 1941, THE MUSEUM OF MODERN ART INVITED HIM TO DESIGN A PHOTO EXHIBITION ON THE THEME OF NATIONAL DEFENSE.

He first tried to reenlist in the military in the fall of 1940 but was turned down. In October 1941, the Museum of Modern Art invited him to design a photo exhibition on the theme of national defense. He selected the photographs; his brother-in-law, the poet Carl Sandburg, wrote the captions. Before they completed the work, the Japanese attacked Pearl Harbor, and when the exhibit was hung in May 1942, it was called "The Road to Victory," in order to promote the war effort.

In the meantime, Steichen continued his efforts to serve in combat, eventually coming to the attention of a Navy captain, Arthur Radford, who would later become chairman of the Joint Chiefs. Late in 1941, Radford was in charge of Navy pilot training. With the responsibility to recruit up to 30,000 pilots a year—in the face of stiff competition from the Army Air Forces—Radford saw the wisdom of exploiting the talents of Edward Steichen.

"I received a telephone call from the Navy Department in Washington asking me if I would be interested in photographing for the Navy," Steichen recalled in his autobiography *A Life in Photography*. "I almost crawled through the telephone wire with eagerness."

Composition is a hallmark of Steichen's crew, in action shots—firefighters on the USS Intrepid *(above)—and repose: Marines in the crook of a Corsair's wing (opposite). Right: The famous flag photo.*

According to photography historian Christopher Phillips, author of *Steichen at War*, Naval photography prior to World War II depicted "machines, equipment, ships, airplanes." Wayne Miller, a wartime photographer who worked for Steichen, says photographers made images of "formal occasions on board ship, ceremonies such as crossing the equator, broken parts."

But Steichen had joined up to run an advertising campaign: Your Navy at War. Peter Galassi, curator of photography at the Museum of Modern Art, says that in choosing what to photograph, Steichen "was selecting for really good advertisements."

An outstanding example, taken in October 1942, shows the U.S. flag flying over the flight deck of the escort carrier *Santee*. *U.S. Camera 1944*, a major photo annual, stated that "no picture taken during the war has had as great popular usage as this one. It has been on magazine covers, in newspaper pages,

Steichen made this ghastly post-battle photo on Iwo Jima. Right: A cinematic scene in the USS Yorktown *ready room. Far right: War is work on the USS* Saratoga *deck.*

on posters. Almost every editor who has seen the picture feels that it is the perfect flag photograph."

Horace Bristol, who took the photo, was one of the men whom Steichen recruited. Most came in as civilians; Bristol had been with *Life* from the first issue and had accompanied writer John Steinbeck during the travels in California that inspired *The Grapes of Wrath*. Charles Fenno Jacobs, another recruit, also had worked for *Life*. Charles Kerlee had made his name as an outstanding commercial illustrator. Victor Jorgensen had built a strong reputation at the Portland *Oregonian*. Wayne Miller, the only rookie, was already in the Navy and showed Steichen a portfolio, hoping to join his crew. Years later, Miller recalls Steichen telling him, "It wasn't your photos that impressed me; your photos were lousy. It was your youth and enthusiasm."

Seen today, some of their work has an old-fashioned, message-laden quality. Phillips notes that the photos "appear too technically perfect, too perfectly composed." On Iwo Jima, for instance, Steichen photographed the fingers of a Japanese soldier protruding from a shallow grave. Phillips says the photo makes him wonder if Steichen enhanced the scene by brushing away dirt.

Bypassing the Navy photo organization, Steichen drew on Radford's support to gain unprecedented independence. His photographers avoided Navy-issue cameras, choosing their own models. They did not develop their film in the field but sent it to a lab that Steichen operated in Washington. Steichen exercised tight control over the developing and printing, emphasizing repeatedly that he wanted dark prints with excellent contrast. When Steichen himself photographed a Grumman F6F Hellcat fighter taking off from the deck of the USS *Lexington*, he caught the aircraft within a pool of what might have been reflected moonlight. In fact, the photo had been

The Hellcat is real; the moonlit sea, an effect. Opposite: Not a movie star (top), but a pilot shot by a fashion photographer. The captain (at right) in an arrangement of circles.

"ABOVE ALL, CONCENTRATE ON THE MEN. THE SHIPS AND PLANES WILL BECOME OBSOLETE, BUT THE MEN WILL ALWAYS BE THERE."

made on a bright afternoon.

Radford interceded with Admiral Chester Nimitz, commander-in-chief in the Pacific, to win the right for Steichen and crew to virtually write their own orders. Barrett Gallagher, who joined the group in 1944, later wrote of requesting duty on the staff of a certain admiral: "He had not heard of me and he asked what my orders were. I told him my orders were to go anywhere I liked, do whatever I wanted, and go home when I felt like it. After he had read them he said, 'Damned if they don't' and took me on."

Still, it took more than professional freedom and tight technical control to make really memorable photos. At times, it took luck. Steichen won a combat assignment when he embarked on the *Lexington*, which supported the invasion of Tarawa, one of the most significant battles in the Pacific campaign. A Japanese torpedo crippled the ship's steering and a misfiring machine gun sent a stream of rounds in his general direction, but Steichen failed to capture a good shot of the action. The war's great action shots—a kamikaze attack on the carrier *Bunker Hill*, for example, or the USS *Yorktown* at the moment its hull was blasted by a torpedo during the Battle of

Midway—were made not by the artists under Steichen's command but by ordinary combat photographers. The enlistees, notes MoMA's Galassi, "made one great picture after another. They made extraordinary pictures, not because they were art photos, but because they were trying to describe what was there in front of them."

What, then, did Steichen and his men contribute? His own directions to his photographers were, "Be sure to bring back some photographs that will satisfy the Navy brass, but spend most of your time making those photographs which you feel should be made. Above all, concentrate on the men. The ships and planes will become obsolete, but the men will always be there."

He provided the model for them to follow in mid-1943, when he visited submarine facilities at Groton and New London, Connecticut. Here his chief subjects were the workers. A portrait of a woman in saddle shoes and jeans, poring over a blueprint, is reminiscent of his pre-war fashion photography.

When the war ended, Steichen returned to the Museum of Modern Art as director of photography and produced the epic 1955 exhibition "The Family of Man." Here, very late in his career, he once again focused on people, the subject that fascinated him throughout the war and throughout his life.

Didi & Sigi's Excellent Collection

by Bettina H. Chavanne

WANTED: AIRPLANES. MUST BE FLYABLE—EVENTUALLY.

CORNELIUS BRAUN

DIETRICH MATESCHITZ, the creator of the energy drink Red Bull, has money. Lots of it. His decision to spend some of it restoring and operating a collection of airplanes involved a 58-year-old named Siegfried "Sigi" Angerer, an 18,000-hour pilot who claims he is the one who taught a nervous Mateschitz to fly.

"The first plane I took Didi for a ride in was a Piper Cub," says Sigi. "He was a bit afraid of flying at the time. He couldn't understand how a plane made from cotton [and steel tubes] could fly. He got used to it."

Another version of the story says that Mateschitz was not afraid of flying. He already had his pilot's license when he met Angerer and had coined his company's slogan, "Red Bull gives you wings." But Mateschitz had learned to fly from a crummy flight instructor, so he relearned at "Sigi fighter pilot school," in the words of Gerd Strobl, quality manager of the Flying Bulls, Red Bull's aviation-focused subsidiary.

This much is uncontested: The first meeting between Angerer and Mateschitz was propitious. In 1990, Angerer was flying a Vought F4U Corsair at an airshow in Innsbruck, Austria. He'd bought the airplane in Texas a year or so prior, using up all his savings from his day job as a corporate pilot, and now was struggling to make enough money to maintain the old airplane.

"Didi saw me fly," says Angerer, "and when I folded the wings down he said, 'Red Bull gives you wings—that airplane fits perfectly with [our slogan]!' "

Mateschitz asked to sponsor the aircraft, and Angerer gladly plastered the Red Bull logo on the Corsair's fuselage. Within a few years, Angerer came to work for Red Bull. The friendship between the men is the foundation of the Flying Bulls.

"I came to Salzburg six years ago," Angerer says. "[Mateschitz and I] found out we're from the same area, we drive the same car, we have the same interests." Whatever aircraft Sigi wants, he buys. Whatever airplane catches Mateschitz's eye, he discusses with Sigi before buying. It's a unique partnership between two very different men.

Mateschitz, 62, is handsome, tan, tall, and stylishly dressed. Angerer is a rumpled old guy in a flightsuit. Together, they have established a stunning home base high in the Austrian Alps that serves as Flying Bulls' headquarters. Their centerpiece is a building known simply as Hangar-7, which looks like a beautiful, shiny egg, sliced in half, on an angle…sort of. The history of this enterprise begins in Innsbruck, 85 miles from Salzburg, in 1997.

"We had a dream to buy a B-25," Angerer says. He prefers airplanes from the United States because he claims German craft "aren't so interesting, and there aren't many left.

"We went to the U.S. and found [the B-25] in terrible shape in Kansas City. It looked like a fish carcass...but the structure was very sound." Angerer flew it until he got used to the old airplane, adding: "We had to add 20 liters of oil per hour on one engine."

A two-and-a-half-year overhaul followed. Once the airplane was fully restored, Angerer flew it from Texas to Innsbruck, a flight lasting 27 grueling hours.

"It was very nice," he says sardonically. "We flew at 5,000 feet...[in] very bad weather, rain, storms. The waves were like houses."

The Red Bull ground crew hangared the new acquisition in Innsbruck, and Angerer spent the next several years based there while flying airshows for Red Bull. When hangar space opened up in Salzburg, where Mateschitz was living at the time, the two men jumped at the opportunity for more room for their aircraft.

On August 22, 2003, the elliptical

CAROLINE SHEEN

The hills are alive with the sound of a restored B-25 (above). The World War II bomber is a prime example of the perfectly polished aircraft in the Flying Bulls collection, which resides in picturesque Salzburg, Austria. Museum founders and best pals "Sigi" Angerer and "Didi" Mateschitz are as different from each other as the Alpha Jet is from the Falcon Jet (right).

CAROLINE SHEEN

The highly stylized Carpe Diem lounge looks out on a rotating exhibit of aircraft and art in Hangar-7.

glass Hangar-7 opened its doors to the public. The floors were buffed to a shine, the aircraft were displayed in all their glory, and a ritzy on-premises restaurant called Ikarus held a grand opening.

As the Flying Bulls collection and staff grew, so did their need for yet another space dedicated solely to their airplanes. Ground was broken for Hangar-8 in May 2002, and in December 2003, the last piece of curved and pressure-treated glass was dropped into its frame. Now there was a place for maintenance (Hangar-8) and a place for exhibits and fancy parties (Hangar-7).

The separation between the glamorous and rather leggy staff of Hangar-7 and the maintenance team in Hangar-8 is rigid. Socializing between the two is actively discouraged. Hangar-7 falls under the purview of Red Bull, which is a separate entity from the Flying Bulls. The world-renowned restaurant, Ikarus, with its list of star international chefs who do guest stints; the chic lounge, Carpe Diem, where guests sip exotic tea and bask in the view of the airplanes and the Alps; the Mayday bar, with its moody lighting and thumping music; and the Threesixty bar, with its transparent floor overlooking the hangar—all are part of an image Mateschitz cultivates for his brand.

Last summer the hangar featured the work of consumers from around the world who had been invited to create sculptures out of Red Bull cans. Admission to the Red Bull museum in Hangar-7, which features a rotating exhibit of aircraft and art, is free.

Hangar-8, on the other hand, is the boisterous sibling, and is closed to the public. Jokes fly, props spin, and guests arrive piloting their own warbirds. And, of course, everyone is pounding Red Bull like it's water. Coolers filled with the stuff are all over the place.

Today, the Flying Bulls' ever-growing collection comprises a North American T-28B Trojan, a North American B-25J Mitchell, a Cessna C208 Amphibian Caravan, a Vought F4U-4 Corsair, five Fairchild-Dornier Alpha Jets, a Pilatus Turbo Porter PC-6/B2-H4, and a Pitts S2B.

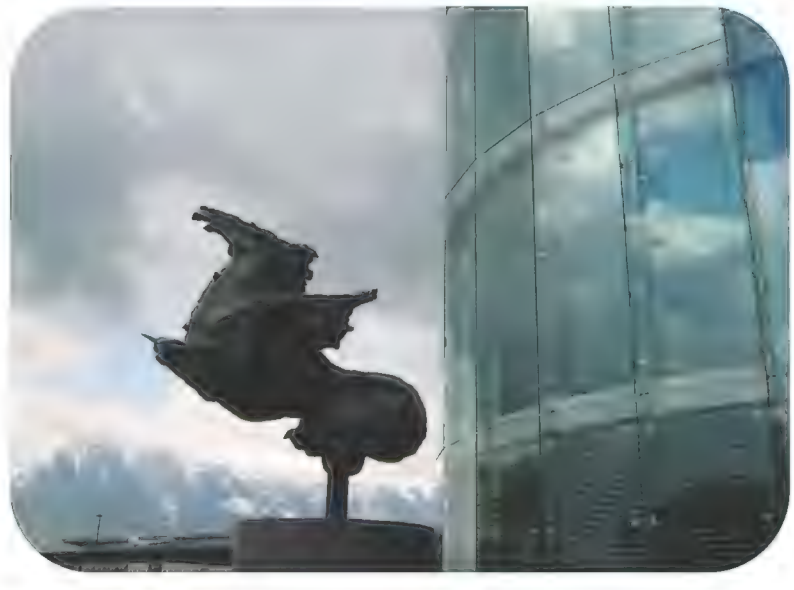
There are also a couple of helicopters (including a decommissioned Bell AH-1Z Cobra), race pilot Lefty Gardner's old Lockheed P-38 Lightning—currently being refurbished in Texas—and a Fairchild PT-19 and Boeing Stearman being refurbished in Hangar-8.

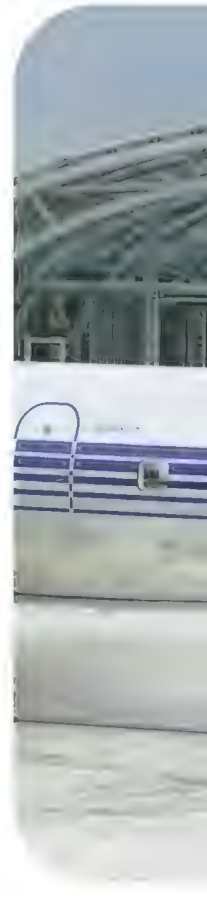
But the Douglas DC-6B is the centerpiece of the collection, not so much because of its size as because of the effort it took to get it into the near-perfect condition it's in today. The airplane has an interesting provenance: It was the second to last one off the production line in 1958, and it was delivered—along with its sister aircraft, the last DC-6 ever produced—to the national Yugoslavian airline, JAT.

Head of state Marshal Josip Tito had other plans, however, and converted them both into luxurious private transports for his own use. In 1975, Tito sold the DC-6s to the Zambian air force, which stored them at a remote airport for about 12 years, then used them to fly sightseers over west Africa until 1999.

In March 2000, Angerer read in an airline magazine that the aircraft were for sale, and he and Harald Reiter, the Flying Bulls' general manager, set out to buy one. They chose the penultimate one off the production line, and on July 7, 2000, they fer-

Pegasus, *by Tyrolean sculptor Jos Pirkner, stands guard outside Hangar-7.*





CAROLINE SHEEN (2)

ried their new DC-6 home, a trip that took them 26 hours.

"We didn't have a hangar yet, so we started to disassemble the airplane outside in the field, in the grass," says Thomas Muigg, now Flying Bulls' maintenance and technical manager as well as the DC-6's flight engineer. In 2000 he was hired to head up the restoration. The maintenance team ended up replacing 78 percent of the aircraft's structure. The airframe had only 6,000 hours, but was plagued with corrosion. In addition, as team members started to take apart the inner walls of the aircraft, they discovered hundreds of African wasps' nests. The entire restoration took about 30 men four years.

A few months prior to the DC-6 project's completion, a Flying Bulls crew was sent to Alaska to check out Northern Air Cargo, the operator of the world's largest DC-6 fleet and home to a huge training and simulator facility.

"Word trickled down to me about the restoration they'd done on the aircraft and the fact that a green crew was going to fly the airplane on its certification flight," says Doug Lee, a DC-6 pilot of 52 years, then with Northern Air Cargo. "I told them they needed someone with experience to fly the plane, and I offered to do the certification flights for them." Angerer agreed, inviting Lee to Salzburg to helm the DC-6 as chief pilot and to make the certification flights. Lee is now a permanent fixture at Flying Bulls.

Nearly every aircraft in the collection has its own interesting history—and maintenance peculiarities. A specialist is assigned to each airplane. On aircraft like the B-25 and the DC-6, one flight hour equals about 50 maintenance hours. Although parts can be found relatively easily and cheaply, it's hard to predict what condition they'll be in when they arrive. Recent parts purchased from the military are usually in pretty good shape, but often parts require intensive and time-consuming labor to get them in working order.

The facilities at Hangar-8 are approved by the European Aviation Safety Agency (the equivalent of the U.S. Federal Aviation Administration).

"With the DC-6 project, we learned we had to do everything in-house," says Muigg. "We couldn't rely on other maintenance facilities. No one [we talked to about restoration] wanted to take the risk of restoring an old airplane."

There's also a complex hierarchy involved in keeping so

The many faces of Red Bull: Thomas Muigg does a walk-around of the DC-6 (below), dueling aerobatic aircraft (right), and an unusual view of the hangar through the Threesixty bar's glass floor (far right).

KAROLY ARVAI

CAROLINE SHEEN

CAROLINE SHEEN

In Hangar-8, the Flying Bulls fleet vies for floor space and maintenance time. Clockwise from bottom: Pitts Special, Falcon 900, Cessna Caravan, B-25, Alpha Jet.

many pilots current on so many different airplanes. "Every airplane has one pilot assigned to take care of it," Angerer explains. "They fly that aircraft mostly, but they are also current in at least two kinds of airplanes. The rule is, you can fly your airplane once every two weeks without asking."

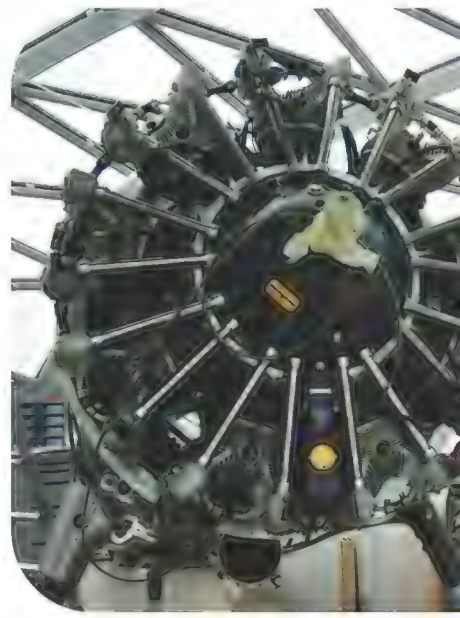
Angerer maintains a grueling work schedule. "This company started with just a few planes, [so I did] lots of flying, not much work," he says. "Now, with 22 planes, [I do] a little less flying and much more work."

Of the more than 70 types of aircraft Angerer has flown in his career, he has several favorites: He especially likes his Piper Cub, in which he taught Mateschitz how to fly. "For fun, it's the Alpha Jet," he adds. "For serious flying, the [Falcon] 900."

Angerer was single-handedly responsible for getting the Flying Bulls its Alpha Jet fleet. Recalling his first attempts to purchase the aircraft, he says: "It was a dream of mine, but the German military didn't sell to private people."

The Alpha Jet was designed by Dassault and Dornier in the 1970s as a dual-purpose trainer and light attack jet. In the early '90s, the German Luftwaffe decided to retire its Alpha Jets. Before they were auctioned off, their wing spars were cut so the military jets couldn't be used privately. Angerer purchased two anyway, and those are used for exhibit and replacement parts. In 2001, an opportunity arose for Flying Bulls to acquire two Alpha Jets (this time in flight-ready condition) directly from their manufacturer.

The Flying Bulls restored the Alpha Jets, making them the first of their type to be demilitarized and licensed for civilian use. They were put into operation flying around Europe. A couple of years later, the Flying Bulls bought their third Alpha Jet.



The hangar is a busy place, but also noticeably, and almost shockingly, clean. In the engine shop, each tool is lined up perfectly in size order, beneath an engine there's a drip pan without a drop of oil in it, and the engine itself (which is supposedly in need of an overhaul) is as clean as a mirror. "It's an Austrian thing," says Gerd Strobl. "We're sort of anal."

"Operating old planes—you have to have a certain sensitivity for them," says Muigg. "The older aircraft need tender loving care. Scheduled maintenance is only ten percent of your work. Ninety percent is just constant care.... You

have to keep an eye on everything. You can't assume you can only go by the manufacturer's inspection schedule."

Muigg is a perfectionist—in a video of the DC-6 restoration, he goes over every inch of the aircraft's stripped interior with a flashlight and a dentist's mirror. He's Austrian.

Later, the DC-6 is prepped for a flight. As the crew revs up the engines, each Pratt & Whitney R-2800 coughing, sputtering, and then roaring to life, Muigg does a complete walk-around of the aircraft. He stops periodically to shout something up to the copilot, or to indicate to one of the maintenance team that something needs checking. In one particularly terrifying moment, Muigg directs a crew member behind one of the enormous props to monitor a potential oil leak. The man climbs a ladder placed directly beneath the cowling, the blades spinning inches from his head. He gives the thumbs-up first to Lee and then to Muigg, climbs down nonchalantly, and folds up his ladder. We're cleared for takeoff.

CAROLINE SHEEN

Time travel: Flight-seeing over the Austrian Alps in the Flying Bulls DC-6 recalls a more glamorous era in aviation.

CORNELIUS BRAUN

A DC-6's engine and a Boeing Stearman wing enjoy equal care from the maintenance crew in the meticulously organized Hangar-8 (below). Right: The Vought F4U Corsair that literally gave Red Bull its wings.

CAROLINE SHEEN

It takes three people—pilot, copilot, and flight engineer—to operate a DC-6. Strobl, in his personal writings on the aircraft, notes, "To bring the landing gear up or down, you are pushing or pulling a big red lever. Sometimes with both hands, if you haven't been to the [gym recently].... We are talking about serious aviation machinery here."

As Captain Doug Lee swoops between the Alps and tips the polished wings to offer a better look, passengers in the spacious cabin take in a rare close-up view of Austria from about 5,000 feet above valley level.

The Flying Bulls aircraft collection shuttles from airshow to airshow around the globe. The Red Bull aerobatic team—which at times accompanies the Flying Bulls and other times flies exhibitions on its own—has performed the world over, from Nellis Air Force Base in Nevada to its home turf in Austria. The larger aircraft, like the DC-6, are parked row upon shiny row in static display for the visitors.

At this year's AirPower 2005, Austria's largest airshow, 250,000 people came to watch the Flying Bulls fly and display their hardware. There are also Red Bull-branded aircraft on the Red Bull Air Racing World Series circuit. These particular pilots fly their aerobatic aircraft through a terrifying slalom course, zipping between enormous plastic pylons at dizzying speeds (see "Red Bull's Rodeo," Apr./May 2005).

A large part of the genius of Red Bull lies in its marketing. The flashy flying and the gorgeous airplanes are evidence of Mateschitz keeping tight control on how his brand is presented to the world at large. He markets the energy drink directly to participants and hangers-on at extreme sports events, airshows featuring his aerobatic racing team, and the ultra-luxe Formula 1 auto racing circuit. For the moment, Mateschitz refuses to send the Flying Bulls team to France for any airshow demonstrations because France hasn't yet authorized the beverage's sale. The French are wary of the high caffeine level (80 milligrams per can—less than the amount in a cup of coffee), as well as the as-yet unquantified effects of the other two primary ingredients, taurine (an amino acid) and glucuronolactone (a carbohydrate).

France's position aside, it doesn't look like the Flying Bulls will be grounded anytime soon. There are just too many exciting aircraft types out there waiting to be adopted by Mateschitz and dressed in Red Bull's brilliant colors—like the de Havilland DH-110 Sea Vixen emblazoned with the familiar logo that recently overflew an airshow crowd in Austria. The only question remaining is, Where will they all fit? Hangar-9, anyone?

MACH 1 *for* MILLIONAIRES

THE CHALLENGE OF BUILDING A SUPERSONIC BUSINESS JET.

by Mark Huber illustration by Paul Dimare

For the moment, the supersonic business jet—especially one flying over land—is a mythical creature.

The pilot lines the Learjet up on the runway and pushes the throttles forward. Across the field at southern California's Van Nuys Airport, the conference room's windows vibrate a little. Inside, Clay Lacy leans across the table and shakes his head. "The most amazing thing to me about aviation is how slow we are going. We are basically flying at the same speed we did in 1959 when the [Boeing] 707 came out."

Just beyond Lacy's windows, a fleet of $30 million Gulfstreams and sleek Learjets crowds the airport ramp. Van Nuys is a concertina-wire-ringed cornucopia of all things that fly, save airliners, located smack in the middle of the San Fernando Valley. From opulent Boeing Business Jets to privately owned warbirds to lowly Cessna 152 trainers, it's all here. The place reeks of kerosene and money.

Clay Lacy is a retired United Air Lines Boeing 747 captain. Over six decades he has flown everything from DC-3s to Mach 2 fighters. Today, he owns Clay Lacy Aviation, an executive aircraft charter, management, and service company, and is a leading spokesman for corporate aviation.

Since 2001, Lacy has served as an advisor to Supersonic Aerospace International, a venture committed to building a supersonic business jet (SSBJ). In October 2004 SAI unveiled its design for an SSBJ at the National Business Aviation Association annual convention. At the same convention another company, Aerion Corp., a Reno, Nevada-based company founded in 2002, announced its intention to build a competing supersonic jet.

The two announcements were accompanied by a sea of press releases, a torrent of publicized patent filings, artful models and renderings, and much talk about the need to enlist "risk-sharing partners" to help finance what will surely be a long, expensive, and technically and politically challenging endeavor.

The overall development cost for each program was pegged at $1.5 billion to $3.5 billion, and the per-aircraft price was estimated at $80 to $100 million. Surveys had shown a potential market for 300 aircraft worldwide, about par for deliveries of a successful bizjet.

The team members behind these designs had impressive pedigrees, but

NASA LANGLEY RESEARCH CENTER

NASA DRYDEN RESEARCH CENTER

A Supersonic Laminar Flow Control model of the F-16XL takes a trip through the wind tunnel at NASA's Langley Research Center in Virginia (left). The 10 million laser-cut holes on the F-16XL's wing "glove" (right) increased laminar flow by suctioning boundary layer air through the glove's surface, expanding the area of smooth airflow.

the members of the NBAA were still skeptical, for it was not the first time the supersonic tease had been danced before them. In 1989, U.S. business jet builder Gulfstream teamed with the Soviet Union's Sukhoi design bureau to launch the S-21, and in 1998 French jet fighter and business jet maker Dassault took the wraps off a trijet SSBJ design. Then, the unsolved problems of mitigating the sonic boom, developing durable engines, and shifting corporate priorities relegated these projects to the back burner. But for many in the corporate jet community, the dream of speed was never far away. And a near-supersonic airplane called the Citation X had whetted a lot of appetites.

Cessna, a company known for its line of small- and medium-size Citation business jets, delivered its first Citation X in 1996. The "Ten" had a plain vanilla, eight-seat cabin and sold new for $12 million. But it could cruise at 49,000 feet at .92 Mach and was rumored to have broken the sound barrier during flight testing. With the Ten, Los Angeles to New York became a four-hour trip, beating the competition by over an hour.

Golfing legend and seasoned bizjet pilot Arnold Palmer took delivery of the first Ten. In 1997, he told writer Jeffrey Rodengen about a conversation he'd had with an air traffic controller as he flew his Ten past the slower airliners. "The other day, on a trip down to Florida, the air traffic controller said, 'Hold up a minute Arnie. I'm going to see if that pilot ahead of you will let you play through.' "

Ten operators love it, demonstrating to the bizjet community what automakers have known for years: Speed sells. But the Ten also showed that you could get that speed for less money than had previously been assumed. Today, the Ten costs a little more than half of a new and much larger Gulfstream 450 and burns about 40 percent less fuel flying the same mission.

The same year the Citation X made its debut, Boeing and General Electric announced the launch of the Boeing Business Jet, a modified 737 airliner outfitted with longer-range fuel tanks and winglets. Customers would buy the BBJ "green," or unfinished, for around $33 million, then spend whatever they wanted on custom paint and interiors. And spend they did, with the average BBJ finished price heading well north of $50 million. Prior to the BBJ, the top-end market for corporate jets ran in the $40 million range. Of course, there were well known exceptions to even this level of excess: The Saudi royal family had been outfitting 747s and Lockheed L-1011 jumbo jets as flying palaces for years, and at nine-figure prices few could fathom. But the market was shocked by the BBJ's level of success—100 have been delivered through mid-2005—and it wasn't long before Airbus rushed to market with a competing aircraft. The BBJ demonstrated that, within the corporate jet market, there were customers in a rarefied niche who would spend almost anything if it meant they would be flying a much larger aircraft.

But even with this seeming disregard for price and the confirmed need for speed among bizjet buyers, supersonic has long been the third rail of commercial aviation. For decades, analysts and manufacturers have viewed a supersonic aircraft as noisy, financially risky, and politically toxic. In the United States, supersonic flight over land by any non-military aircraft is, in fact, illegal (Federal Aviation Regulation 91.817). Many other countries have adopted similar prohibitions.

Beginning in 1958 and largely in response to the supersonic Anglo-French Concorde airliner, the United States sank more than $1 billion into civilian supersonic research, capping it with the very public cancellation of its supersonic transport program in 1972. For those who opposed it, the SST embodied all things wrong with technology. In his 1970 anti-SST tome, William A. Shurcliff, director of the Citizens League Against the Sonic Boom, perfectly captured the histrionics of SST opponents when he wrote: "If overland supersonic flight is permitted, 500,000,000 persons in America, Europe, and Asia may be jolted every hour, day and night by sonic booms from hit-and-run SSTs. People work-

ing, relaxing, sleeping will be banged repeatedly, without apology. Surgeons performing delicate operations will be startled, and their instinctive reflex reaction may cause permanent harm to the patients.... Aviation, instead of being man's servant, would be his scourge."

The abrupt death of the American SST program, coupled with the slow bleed outs of the Soviet Tu-144 and Anglo-French Concorde programs, did not end research into supersonic transport, but did slow it down. In the United States, funding for such research dropped from about $100 million a year to $13 million under the guise of NASA's Supersonic Cruise Research program. But even as the anti-SST drumbeat was reaching its crescendo, science was getting results that would make the protests irrelevant. It just wasn't happening fast enough.

In 1964 NASA scientist F. Edward McLean hypothesized that changing an aircraft's shape could minimize its sonic boom. Seven years later, two scientists at Cornell University, Richard Seebass and Albert George, published an algorithm "for defining the minimizing equivalent area distribution based on flight Mach number and altitude, and the aircraft's length and weight." In other words, it was not only possible to mitigate an aircraft's sonic boom by altering its shape, you could also use a mathematical model to predict the boom signature of any given shape. NASA validated Seebass-George during 1972 wind tunnel testing for regimes at Mach 1.5 and 2.7. (The model was more accurate at the lower Mach number.) However, it would be more than 30 years later, on August 27, 2003, that these theories were tested on an actual aircraft by the Defense Advanced Research Projects Agency's Shaped Sonic Boom Demonstration, part of DARPA's Quiet Supersonic Platform program (see "The Boom Stops Here," Oct./Nov. 2005).

Predicting and quieting sonic booms are only part of the new science driving the development of the supersonic business jet. The other involves supersonic natural laminar flow.

An aircraft experiences a certain amount of drag from skin friction as air moves across the wing and gives rise to turbulent "boundary layers." Laminar flow describes air immediately next to the wing, which flows in a series of smooth layers, free of turbulence, resulting in less aerodynamic drag on the wings and improving range, speed, and fuel economy. It is virtually impossible to achieve extensive laminar flow on a subsonic aircraft. Supersonic aircraft offer more possibilities, but their potential for laminar flow is often defeated by design factors, like a highly swept wing, which invariably creates turbulence and drag.

NASA experiments in 1995 and1996 used the delta wing on an F-16XL fighter jet, modified with a power-suction "glove," to improve laminar flow. According to laminar flow expert and aerodynamicist Richard Tracy, a normal F-16 wing "has too much sweep to support laminar flow and has a slightly blunted [wing] leading edge...and thus a very high wave drag at its maximum supersonic speed."

While suction gloves seek to improve laminar flow on swept-wing designs, natural laminar flow relies on a wing's shape alone, without help from other devices. Greater wing sweep produces greater turbulence, thus a natural laminar flow wing has very little sweep, a design that helps stabilize airflow.

The first widely known aircraft to

Cessna's Citation Ten is the closest thing to supersonic on the market.

take advantage of this principle was Lockheed's F-104 Starfighter, a Mach 2 interceptor developed in the 1950s. In 2000, NASA and DARPA teamed up with the Reno Aeronautical Corporation to demonstrate a three- by four-foot natural laminar flow test article mounted to the belly of an F-15B fighter and flown up to Mach 2 at 45,000 feet. The demonstration validated the theory and led NASA to speculate that natural laminar flow had the potential to enable supersonic aircraft to produce "economies comparable to, and in some cases better than, subsonic aircraft in the same role."

Based on these latest rounds of research, two camps sprang up to test the market.

Supersonic Aerospace International was founded in 2001. It is funded by the estate of Clay Lacy's friend Allen Paulson (see "The Used Airliner King," below). Aerion was founded in 2002 and is bankrolled by Texas billionaire Robert Bass.

In 1978 Allen Paulson purchased Grumman's foundering line of civilian aircraft, including the Gulfstream business jet. Over the next decade Paulson shaped Gulfstream into the ultimate status symbol. From corporate chieftains to foreign potentates to the glitterati, nothing said "Mine's bigger" quite like a Gulfstream.

JACK WACHARAMAI SYKES

SAI's Michael Paulson speaks at NBAA in 2004.

By 1985 Allen Paulson had parlayed his 1978 $58 million purchase of Gulfstream into a $637 million cash and stock sale of the company to Chrysler, but stayed on to run the company. He had also launched a wildly successful follow-on aircraft, the G-IV, a 4,000-nautical-mile-range model with all-digital avionics and more fuel-efficient engines. By 1988, Paulson knew what the next big thing was: supersonic.

In 1989 he teamed up with Mikhail Simonov of Sukhoi to develop the Gulfstream-Sukhoi SST, the S-21. Under the plan, Sukhoi would build the airframe while Gulfstream would be responsible for integrating the engines and avionics. The marriage would be short-lived: Chrysler elected to cash out of Gulfstream later that year. The company's new owner was the New York investment banking firm of Forstmann-Little, and it became clear very quickly that the prime target on its radar was not a supersonic bizjet. "In the early 1990s, Gulfstream bet the company on the [development of the long-range, subsonic] G-V," says Pres Henne, Gulfstream's senior vice president for Programs, Engineering, and Test. "Anything else was a very low priority."

Forstmann installed its own CEO to run the company and Allen Paulson retreated to the world of thoroughbred horse racing and other investments.

Although Paulson was out of aviation day-to-day, the idea of a supersonic bizjet "was never far off his mind," according to Clay Lacy. By the mid-1990s he began having regular conversations with engineers and managers at Lockheed's Advanced Development Programs plant (the Skunk Works) in Palmdale, California. One of them was a program manager named Tom Hartmann.

In 1998 Lacy flew Paulson up to Palmdale for a meeting with Hartmann and Ed Glasgow, Lockheed's vice presi-

Aerion's design recalls a prehistoric bird, with its blunted, slightly curved wings and long beak.

The Used Airliner King

Forty years before he bought Gulfstream, Allen Paulson had been working as a hotel janitor in Clinton, Iowa, when he won a $100 bingo game. He used the proceeds to buy a bus ticket to California where he was befriended by a barnstormer named Tex Rankin, who cultivated Paulson's interest in aviation. Paulson enrolled in an airline mechanic training program and was hired for 30 cents an hour at TWA.

After service in the Army Air Forces he rejoined TWA as a flight engineer aboard Lockheed Constellations and started a side business selling aircraft engine modifications. By 1951, Paulson's California Airmotive had become a full-time career and he shifted his focus to buying used airliners and converting them to cargo haulers. In 1967, Paulson founded another company, American Jet Industries, to convert old piston airliners into jetprops. During the 1960s Paulson bought and sold 300 airliners including Constellations, DC-3s, DC-7s, and Electras. In one transaction he snapped up Eastern Airline's entire remaining fleet of 42 piston aircraft. By 1969 Paulson's annual revenues topped $14 million and *Newsweek* proclaimed him the "used airliner king."

"At one time he had more airplanes than a major airline," remembers son Michael Paulson.

Allen Paulson died in July 2000. Just a year later, Michael, himself a veteran of the bizjet industry, formed SAI and hired Lockheed to conduct SSBJ feasibility and design studies.

PAUL HARRIS/GETTY IMAGES

Allen Paulson, pictured here at his office in La Jolla, California in 1996, looked for speed in racehorses as well as in airplanes. He was one of the prime movers behind the development of a supersonic business jet.

The Challenger

Richard Tracy built his first model airplane when he was five and started attending the free Friday night lectures at the California Institute of Technology when he was 13 years old. While his classmates were grooving to Benny Goodman, Tracy was immersing himself in high-energy physics. He made extra money washing and polishing airplanes on weekends and soloed at age sixteen. His favorite airplane was a 1936 Taylor Cub. "Forty horsepower and no brakes," he recalls.

BELOW COURTESY AERION CORP.; LEFT CHAD SLATTERY

Robert Bass, Brian Barents, and Richard Tracy pose with their model at NBAA in 2005.

Tracy received his undergraduate and masters degrees at CalTech before heading off to the NATO-funded von Karman Institute (VKI) for aeronautics and fluid dynamics in Belgium in 1959. It was there that he began to explore the field of supersonic natural laminar flow. His work at VKI convinced him to switch his field of study to aerodynamics, and in 1964 he received a doctorate from CalTech in hypersonic aerodynamics.

At Van Nuys Airport, Tracy became friends with bizjet genius Bill Lear. After Lear sold Learjet and moved to Reno, Nevada, Tracy would visit him there, and it was there that Lear made him an offer he couldn't refuse: chief engineer for a group developing a new business jet called the LearStar 600.

The 600 was a revolutionary design featuring a wide cabin, supercritical wing, and new high-ratio bypass engines that had been developed for Navy submarine-hunting aircraft and the Air Force's A-10 Warthog tank-buster. Lear ended up selling the design and his plans for follow-on jets to Montreal's Canadair, which rebranded the airplane the Challenger 600. Before the Challenger was even on the market, however, Lear tried to interest the company in follow-on designs including supersonic and near-supersonic models. Canadair wanted no part of it.

Tracy, much like his friend Lear, was committed to the idea of supersonic flight. His theories on laminar flow stem from work he was doing when he was still at the von Karman Institute, and they are the foundation for the Aerion's program development process.

dent for advanced development programs. Having successfully launched the G-V, Gulfstream was again able to devote modest resources to supersonic research, this time in partnership with Lockheed and with $20 million in federal support. Lacy recalls the meeting: "They told us they had technology to suppress the sonic boom but gave no great detail."

Paulson died in 2000, and by that time, Lockheed and Gulfstream had parted ways. Gulfstream brought its supersonic research in-house. But Paulson's estate designated funds in trust for the design of a supersonic business jet. In 2001, Paulson's son, Michael, himself a veteran of the bizjet industry, formed SAI and hired Lockheed to conduct feasibility and design studies for a small supersonic business jet. For three years a team of up to 40 engineers ran through $25 million doing just that.

The result is the Quiet Supersonic Transport (QSST), and SAI announced the program at NBAA in 2004. Its designers claimed that its patented sonic boom suppression technology gives it a boom signature less than one percent of the Concorde's.

The Aerion also debuted at NBAA in 2004, and it made another appearance in 2005—with a number of modifications, including the rounding of the wings' leading edges where they meet the wing strake. "A straight edge created too much shock in our wind tunnel tests, and detracted from the aircraft's laminar flow capabilities," said Richard Tracy, Aerion's chief technology officer, at the company's press conference at the NBAA convention (see "The Challenger," p. 45). The aircraft will be powered by a pair of Pratt & Whitney JT8D-219 engines (also found on the McDonnell Douglas MD-80 series), which will provide Mach 1.6 cruise.

While these engines may be quiet enough, questions of durability remain. With the exception of the Concorde's earth-shaking, fuel-ravenous Olympus engines, no civilian jet engine has ever demonstrated robustness at sustained supersonic speeds. Indeed, even most military engines have upper thermal limits, as they typically are thrown into afterburner for only a few minutes at a time. However, the Air Force's F-22A Raptor is equipped with Pratt & Whitney F119 engines and has the ability to supercruise—to fly at supersonic speeds for long periods of time—without the noise and high fuel consumption of an afterburner.

DERRICK CEYRAC/AFP/GETTY IMAGES

Serge Dassault, once a dabbler in supersonics, announced his company's newest long-range bizjet, in February 2005—the subsonic Falcon 7X.

Other than its smaller size, the Aerion, unlike the QSST, contains no specific boom suppression or reduction technology. Because regulations prohibit supersonic flight over land, a potential competitor of Aerion's questions the aircraft's market appeal. "High subsonic overland does not make sense" for a supersonic business jet, says Gulfstream's Henne.

"Our market studies were very explicit that the model in question would *not* be able to fly supersonically over the U.S.," says Tracy. "In fact, the majority [of those surveyed in the Aerion market study] would purchase the non-supersonic overland model," even if a quiet supersonic aircraft that could fly over land were to become available five years down the road.

In Tracy's opinion, "it is doubtful that any definitive regulation [regarding supersonic flight over land] will be forthcoming" before a supersonic bizjet model is built—another reason Aerion isn't focusing on low-boom shaping. "There is a drag penalty associated with aircraft shaping to decrease sonic boom levels," says Tracy. "[And that] translates into larger engines, higher fuel burn…and increased costs."

To the untrained eye, the Aerion resembles an F-104 with an even more pointed nose. It relies on natural laminar flow to achieve speed and economy. It is not surprising that Richard Tracy, who owns Reno Aeronautical Corporation, is one of the company's principals. During the 1980s, Tracy teamed with Stanford University aerodynamicist Ilon Kroo and Jim Chase, a former colleague of bizjet legend Bill Lear, on different configurations for a supersonic transport in their "free time."

"I had this passion since graduate school days to see supersonic become a practical mode of flight," Tracy says. By 1987, the group was on the verge of giving up. "Nothing looked like a significant breakthrough," says Tracy. Then one night he was awakened by the thought "Why not look at laminar flow?" The idea had been in his subconscious since his days at the von Karman Institute in Belgium in 1959. To Tracy, the advantages of a supersonic natural laminar flow wing were abundantly clear. He was confident that others would see so too, and that he would have no trouble securing research funding to prove the concept. He couldn't have been more wrong. For 14 years he was politely received, often more than once, by all the major business jet and airliner manufacturers, a variety of other companies large and small, and a broad cross-section of individual investors. They offered

praise and encouragement, but no funds. Neither did NASA, until the late 1990s, when DARPA came through with funding for the F-15 experiment.

Serendipity struck when Tracy's work came to the attention of Robert Bass, a billionaire with a passion for aviation and technology. Bass hired Michael Henderson, who had managed Boeing's NASA-funded High Speed Civil Transport program during the 1980s, to do further research on the work of Tracy's group. Henderson reported back favorably and Bass invested.

When it comes to the supersonic bizjet, SAI and Aerion are not the only games in town. At NBAA in 2005 Gulfstream focused on its new Supersonic Acoustic Signature Simulator II. The mobile audio booth, housed in a white trailer, enables listeners to experience the loud double-bang of the Concorde followed by the far quieter "Gulfstream whisper," and replicates the sounds in environments ranging from noisy city streets to a playground filled with children. The "whisper" is the sound a supersonic bizjet—traveling at Mach 1.8—would make if it were fitted with a special spike for reducing the sonic boom. The spike, for which Gulfstream received a patent in 1994, would extend from the nose of the airplane during supersonic flight, and retract during subsonic flight.

The simulator is Gulfstream's bid to take the idea of changing regulations regarding supersonic flights over land directly to the people who will be making those changes: Everyone from environmentalists to the Federal Aviation Administration has been invited to step into the trailer and hear, or not hear, Gulfstream's "whisper."

Dassault also continues to work quietly on its designs, and NASA remains a prime funder of supersonic research that someday could be applied to a supersonic bizjet. Its pallet of programs includes the Ultra-Efficient Engine Technology program, which focuses on reduced emissions, lower noise, and higher-efficiency designs.

Currently, NASA is working with a group of 10 companies called the Supersonic Cruise Industry Alliance (SCIA), or the "Super 10." Members include engine builders Rolls-Royce, GE, and Pratt & Whitney; airframers Boeing, Cessna, Gulfstream, Lockheed Martin, Northrop Grumman, and Raytheon; and fractional-share business jet provider NetJets. The group's goal: supersonic civilian flight within 10 years.

A similar group, called HISAC, for High-Speed Aircraft Industrial Project, has been formed in Europe. Members include EADs, the parent of Airbus; Dassault; and Sukhoi.

Last summer, SCIA member companies submitted papers on the state of the art of supersonic technology to NASA as the agency moved forward with funding additional supersonic research, which could include a demonstration aircraft. "It's going to put NASA in the position of being a smarter buyer," says Eric Brachhausen, vice president of American Technology Alliances, a non-profit group that provides coordination services to the Super-10.

Building a successful demonstration aircraft is seen as a crucial step in eliminating the ban on supersonic civilian flight. "Somebody has to build it and the correct agency is NASA," says Gulfstream's Henne, who thinks that anyone who builds a supersonic bizjet before the regulations are changed is shouldering an unacceptable risk. "You don't enter the market while there is still a prohibition." Michael Paulson, on the other hand, says SAI will continue to move forward with or without regulatory changes.

If a supersonic business jet is built, the manufacturer will likely be a consortium of companies. The financial risk and resources required are simply too great for a single company to bear. Brachhausen and others believe that once the technology for a supersonic bizjet is successfully demonstrated, it will quickly be applied to other aircraft, including airliners. "If you focus on the boom first, you are led to the conclusion that the problem is easier to solve in smaller aircraft first," Brachhausen says. "The intent is to bring those principles forward in a larger scale, higher capacity aircraft."

For Richard Tracy, it's not a question of if, but when. "I don't see any reason why this won't happen. And that is the same sense the aircraft manufacturers are coming to."

SAI and Aerion have said that they can have a supersonic airplane flying by 2011. Pres Henne thinks that if regulatory approval can be won, a 2015-2016 window is more likely.

On the day that aircraft first takes flight, people in the world of business jets may reflect on Allen Paulson's contribution. "There were times when he was a lone candle in the wind," says Lockheed's Tom Hartmann. "Ten years ago almost no one was talking about supersonic business jets. Now the whole industry is talking about it. In that sense, he's already succeeded."

And thanks in part to his efforts, one day when a Learjet takes off from the Van Nuys Airport runway and rattles Clay Lacy's conference room windows, it will be followed by a much quieter—and much faster—airplane.

SAI's "joined wing" design, in combination with the shape of the fuselage, disrupts the supersonic shock wave as it passes from the nose to the tail.

COURTESY SAI

Resto

MGM Special | Ryan B-1 Brougham

In 1927, Metro-Goldwyn-Mayer Studios staged a stunt flight carrying Leo, the MGM Lion, from San Diego to New York. (Moviegoers are still greeted by Leo's roar at the beginning of MGM films.)

MGM contracted with the B.F. Mahoney Aircraft Corporation (formerly Ryan Airlines) to modify a Ryan B-1 Brougham, similar to the *Spirit of St. Louis* but with a shorter wing, extra fuel tanks, a cage for Leo, and tanks for milk and water. The pilot was Martin Jensen, who had recently won $10,000 in the Dole Derby, a race staged by the pineapple company for a flight from Oakland, California, to Honolulu. Jensen came in both second and last; only two aircraft made it to Honolulu.

With much fanfare and press coverage, Jensen took off from Camp Kearney, just outside San Diego, shortly after 10 a.m. on September 16. Less than five hours later, he was trapped in a box canyon in what is now known as the Hellsgate Wilderness, near Payson, Arizona. Realizing he could not clear the 6,300-foot-high rim ahead, Jensen landed the airplane in a clump of scrub oaks. The wings and landing gear were torn off before the fuselage tumbled to a stop on its side.

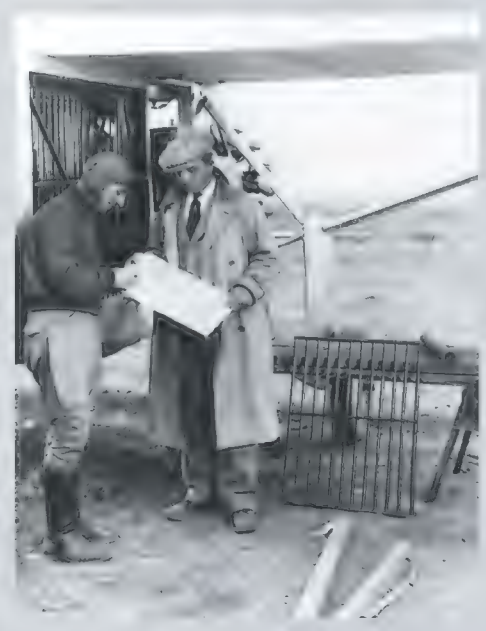
After giving the lion milk, water, and some of his sandwiches, Jensen set off for help. On day four, nearly done in by hunger and exhaustion, he encountered some cowboys, who took him to a telephone. Jensen joked later that, as had happened in the Dole Race, he again came in second: When he called MGM, their first question was "How's the lion?" Leo was returned in good health by land routes to San Diego.

Scott Gifford, a pilot and owner of a restoration and maintenance company, NostalgAire, at Ernest A. Love Field in Prescott, Arizona, first heard about the *MGM Special* in 1982. From a book about aviation in Arizona, he learned about the flight and focused on one sentence: "The wreckage of the plane still lies in Hells Canyon near Payson." Gifford contacted family members of the rescue team and Payson residents, but the project to find the remnants of the Ryan stalled until 1990. That year Gifford was flying a Beechcraft Baron over the Tonto National Forest for the U.S. Forest Service. Looking for Hells Canyon on the charts, he came across a spot called Leo Canyon, named in honor of the lion.

Gifford backpacked into the remote wilderness area several times to search for the remains of the wreckage before he finally found it. "I thought I calmly called everybody down, but I was later teased unmercifully for yelling my fool head off," he recalls. In 1991, he obtained legal ownership of the wreckage and arranged to have it hoisted out by helicopter. He has since acquired another Ryan Brougham and hopes to eventually restore both to airworthiness.

Because so many years had passed before the wreckage was recovered, parts of the *MGM Special* are either missing or in poor condition. "Right

SAN DIEGO AEROSPACE MUSEUM (3)



The Ryan Brougham MGM Special *(top) was a sister ship to Charles Lindbergh's* Spirit of St. Louis. *Pilot Martin Jensen (top, with the Brougham; above, with Leo; and right, going over the flight plan with Ryan company owner B.F. Mahoney) had just placed second in the trans-Pacific Dole Derby.*

r a t i o n

now, it looks like parts of the landing gear and the shock struts can be restored to airworthy condition," Gifford says. "Some of the wing attach fittings will be useable." He uses parts from other Broughams if they are airworthy or can be made so. Otherwise, some components can be used as patterns for reproductions.

A few modifications will be necessary: brakes and a tailwheel, for starters. "You landed going into the wind, and you took off going into the wind," he says. "The airplanes did not have brakes or a tailwheel, just a tailskid. That's what helped keep the airplane going straight and also acted as a bit of a brake. On today's asphalt strips, an airplane with a tailskid and no brakes is going to be uncontrollable."

Gifford got his hands on an overhauled Wright J-5 Whirlwind, the same 220-horsepower engine used in the original aircraft, and a vintage propeller in stellar condition. At the moment he is working on reconstructing the fuselage, rudder, and vertical stabilizer.

He's also searching for components of a Pioneer Earth inductor compass. "It was the unit to have," he says. "It was absolute state of the art." Gifford already has a control head and hopes to find an indicator instrument and a wind-driven generator, which will be mounted on the side of the fuselage.

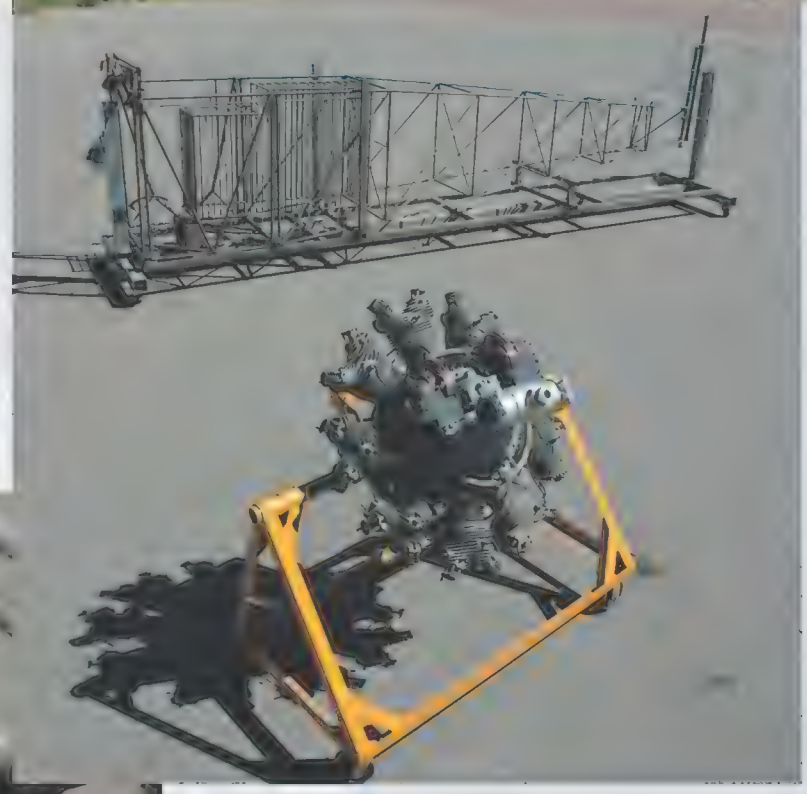
Gifford has no time table for completion. "It will fly on the first—the first chance I get," he says. Whenever that is, a reconstructed cage will house a huge stuffed lion made of plush golden fabric, and Gifford hopes to fly the *MGM Special* to airshows for at least a year.

Gifford recently met with octogenarian Columbus B. "Junior" Haught in Payson. Junior's father, Columbus "Boy" Haught, was a member of the 1927 cowboy rescue team. Junior, who was just shy of four years old when Leo was brought by their ranch, says he still recalls one incident "like yesterday." Two of his mother's chickens were offered to Leo. "It didn't take him but just a swallow to get rid of one of them chickens," Haught recalls, adding that his mom was furious when she found out.

—Gail Hearne

TOM STORY (3)

Framed by the Brougham's enormous rudder, Gifford says he has no deadline for completing the restoration, but when that day comes he'll fly the plane at airshows.



With a Wright J-5 engine and a sturdy cage in the fuselage, Gifford is remaining true to the original—but this time the lion will be stuffed.

Scott Gifford works on the elevator trim mount on the airframe, nearly all of which is a reproduction.

How we got from Point A to Point B.

By Peter Garrison Illustrations by Carl Posey

By Stars, Beacons,

One day this will be an airborne life. But by then men will have forgotten how to fly; they will be passengers on machines whose conductors are carefully promoted to a familiarity with labeled buttons, and in whose minds the knowledge of the sky and the wind and the way of the weather will be as extraneous as passing fiction.

—Beryl Markham, *West With the Night*

To be lost is unpleasant; to be lost at sea or in the sky is particularly so, because the very insubstantiality of the environment infuses it with latent menace. Having been lost, to be found again is inexpressibly exhilarating, almost a rebirth. These experiences, which touch travelers deeply perhaps because they recapitulate the terrors of childhood, may make sailors and airmen shudder in recollection, but at the same time they are an inextricable part of the adventurous life, and so they are in a way precious. All the more now,

One of the most basic forms of navigation, pilotage matches landmarks on a chart with their real-world counterparts.

and Satellites

because the Global Positioning System, the satellite-based means of navigation, is fast making them extinct.

The primitive foundations of navigation are pilotage and dead reckoning. Pilotage is navigation by landmark. The earliest fliers followed rivers and roads from town to town, or, like medieval pilgrims, steered for the nearest steeple. Even the sky itself is a landscape to which a sufficiently sensitive intellect may become attuned: Polynesian "wayfinders" steered their canoes for hundreds of miles with mental sextants and visceral clocks.

Dead reckoning—some say the term comes from "deduced"—means inferring your present position from a knowledge of how long you've traveled, at what speed, and in what direction, from your last. This was the method used by ships before the invention of the chronometer made scientific celestial navigation possible. Dead reckoning is subject to the uncertainty of drift—the unknown component of motion owing to wind or ocean currents. The method sometimes works well—Charles Lindbergh hit Ireland right where he intended to after 20 hours over the Atlantic—but it can also fail, as Lindbergh himself later would, by errors of hundreds of miles.

Nor Dark of Night

In 1918 the U.S. Postal Service, with unbureaucratic daring, inaugurated airmail between Washington, D.C., and New York in Army-surplus Curtiss JN-4D Jennies. Because the distance was so short, the airplane's superior speed gave it only a negligible advantage over ground transportation.

Along the New York-San Francisco route, launched in 1920, there was greater potential for saving time, but darkness was the deal-breaker. When the sun went down, pilots handed their cargo off to trains. President Warren Harding, skeptical of what he perceived to be a costly and inefficient way of delivering mail, threatened to cut off funding.

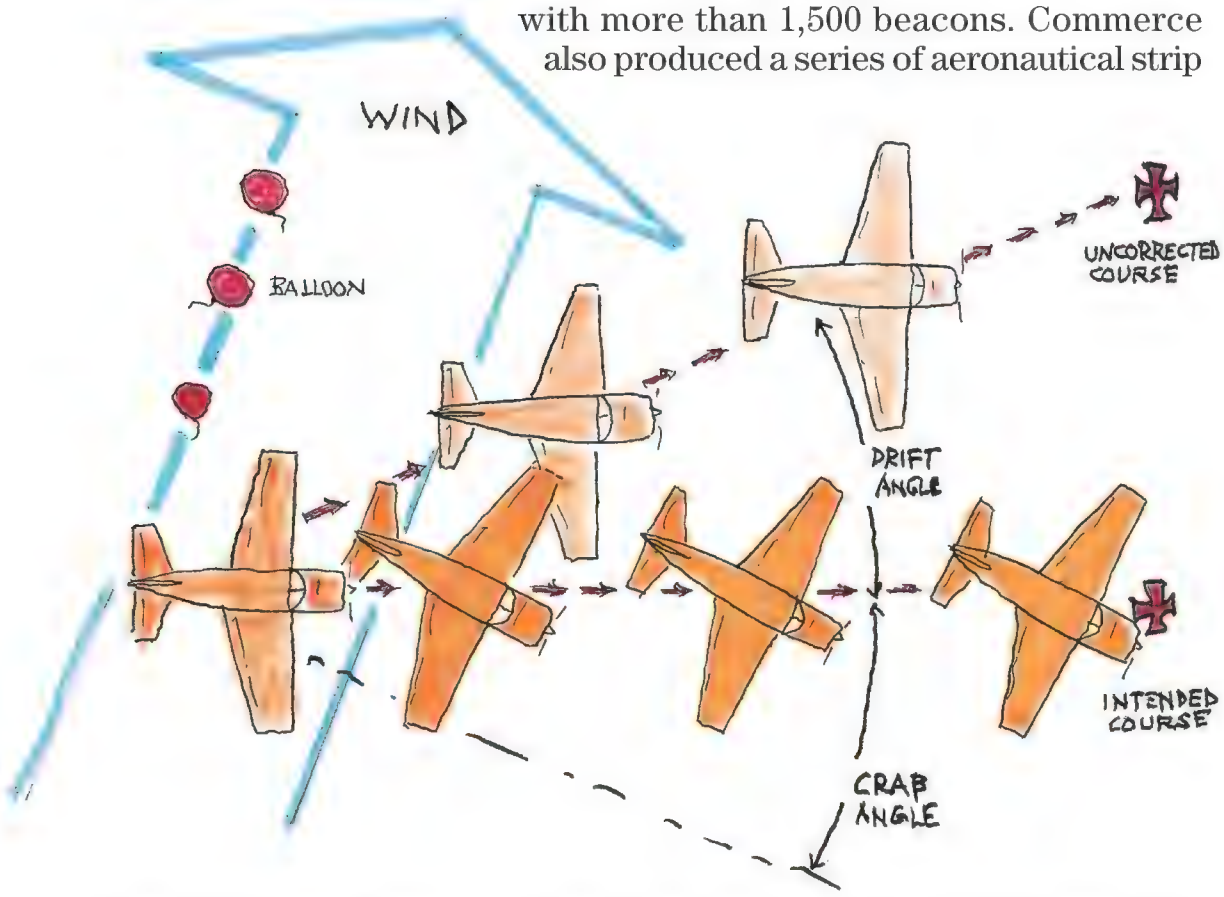
And so in the dead of the winter of 1921—the worst possible time—the Postal Service staged a bold and very nearly quixotic demonstration of fast transcontinental airmail delivery. Four single-engine, open-cockpit de Havilland biplanes took off, two from New York and two from San Francisco. One eastbound pilot was killed in a takeoff accident in Nevada, and the two westbound airplanes, halted by a snowstorm near Chicago, relinquished their cargo to trains.

Pilot Jack Knight saved airmail. Meeting the surviving eastbound biplane at North Platte, Nebraska, Knight took off in darkness. Guided by bonfires and burning oil drums that had been lit by postal employees and helpful farmers, he flew all night in bitter cold, landing to refuel at Omaha and Iowa City, and reached Chicago in the morning. A relay pilot completed the trip to New York.

Dead reckoning is a simple upgrading of pilotage. A pilot computes his present position from data such as travel time, speed, and direction traveled since his last known position.

Having covered 830 miles in nine hours, Knight proved that the airmail could move even in darkness and bad weather. Lionized in the press as a hero (his name probably helped), he downplayed the difficulties he had faced, though he did concede that "if you ever want to worry your head, just try to find Iowa City on a dark night with a good snow and fog hanging around." The trail of fire that Knight followed was the beginning of the nation's first airway system: Funded after all, the Postal Service was soon erecting electric beacons to guide night fliers along its routes.

The Department of Commerce took over responsibility for the system in 1926 and eventually expanded it to 18,000 miles of airways with more than 1,500 beacons. Commerce also produced a series of aeronautical strip charts, the first of which, with topographic, airway, and beacon information for the route from Kansas City, Missouri, to Moline, Illinois, came out in 1927, the year of Lindbergh's flight from New York to Paris. Only three years later, the first aeronautical sectional chart, depicting the Chicago area on a scale of 1:500,000, appeared. Rudimentary instrument approach charts were printed on the back. Aerial navigation, no longer an awkward improvisation upon sea and surface methods, had come into its own.



Wind drift complicates dead reckoning by pushing an aircraft downwind of its intended course. The pilot must calculate the deviation between the intended course and wind-altered course, then turn the aircraft into the wind by that amount to compensate.

Home on the Range

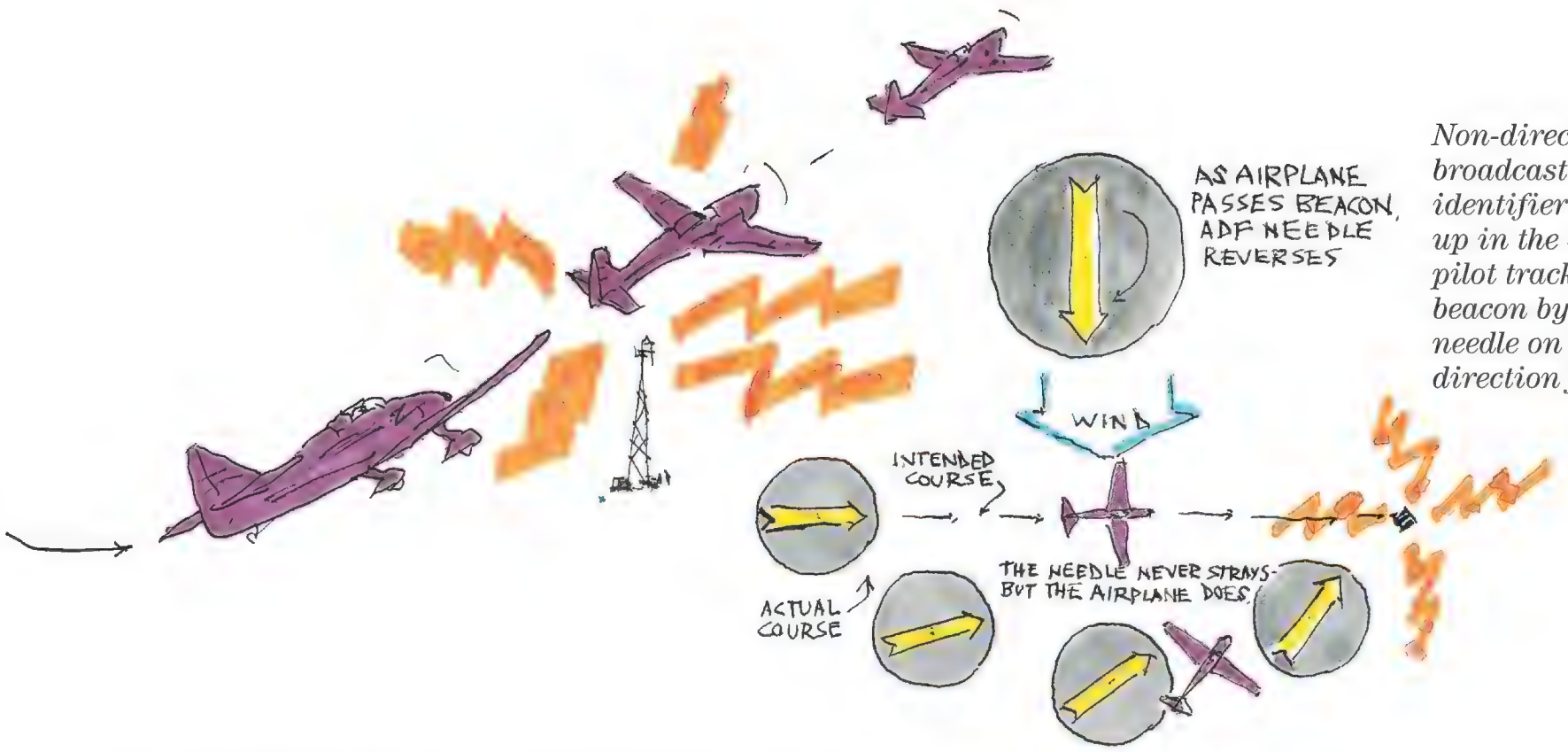
It was evident that airplanes needed radio, both for communication between pilots and the ground and for defining airways that could be followed in bad weather. The 1930s saw the arrival of non-directional beacons and four-course ranges. NDBs mostly operated in the low-frequency band, between 170 and 600 kilohertz, broadcasting a three-letter Morse code identifier. A loop antenna on the airplane rotated (originally, the pilot or navigator turned a crank; later, rotation was made automatic), and the strength of the signal it received depended on the angle of the loop to the beacon. In the automatic version, the Automatic Direction Finder, a needle on the instrument panel showed the direction to the beacon.

Many airplanes still have these because NDBs, being the cheapest kind of ground navigational aids to install and maintain, are still in widespread use. The ADF operates not only in the low-frequency band but up through AM broadcast frequencies as well, so pilots can fly toward powerful broadcast stations in distant cities and, what they sometimes find equally important, entertain themselves by listening to the radio as well.

The four-course or Adcock ranges were low-frequency beacons with four directional antennas, each transmitting a Morse code signal in a lobe-shaped pattern over roughly a quarter of the compass rose. One antenna repeated the letter A—dot dash—while its neighbors had N—dash dot, and the fourth, opposite the first, had A again. Where neighboring quadrants overlapped, the A and N added up to a continuous tone called a course. If the range was near an airport, as most were, one of the courses led to a runway.

A pilot approaching the station likely heard one letter or the other. If he was unsure of his position, he flew until he crossed a course. He then executed a series of turns designed to determine which of the four courses it was, constantly adjusting the radio volume for greatest sensitivity to tell-tale changes in signal strength. He could now fly to the "cone of silence" over the range, track outbound along the approach course for 10 miles or so, then turn and begin his descent to the airport. A skilled pilot flew the "feather edge" of the course, where the faint clicking of a fragmentary A or N could be heard emerging from the continuous hum like a loose thread from a weave.

Over the years we have moved gradually away from aural indications and toward visual ones, and so the difficulty of steering an airplane by varying tones in a headset, and of judging direction by the swelling or fading of a scratchy signal, seems greater to us today



Non-directional beacons broadcast a Morse code identifier that is picked up in the cockpit. The pilot tracks to the beacon by following a needle on the automatic direction finder.

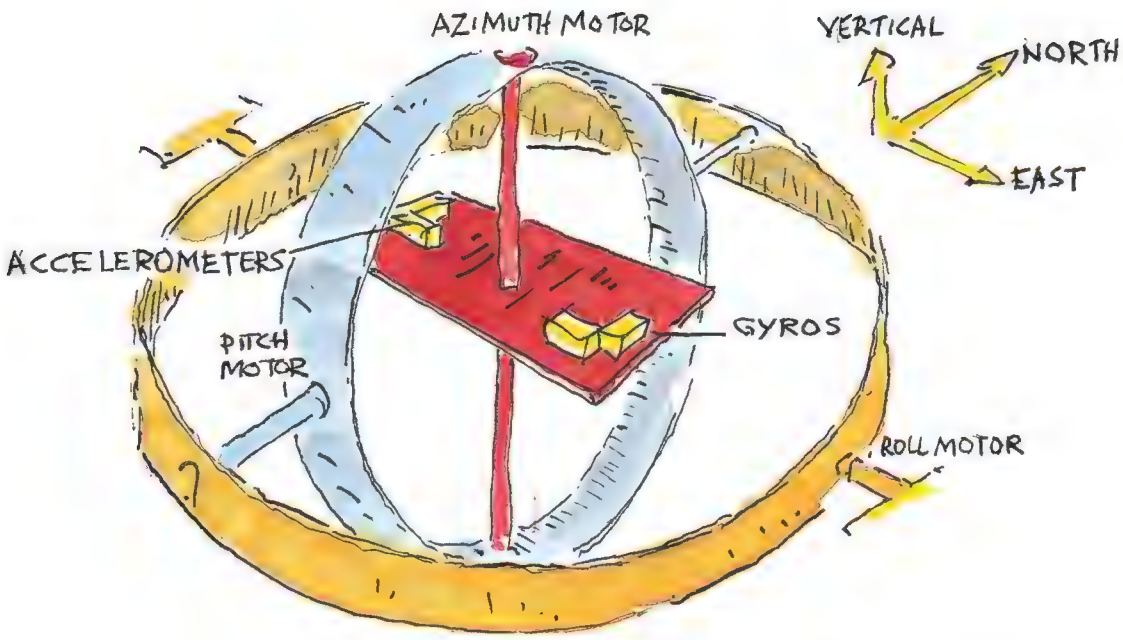
than it apparently did to the DC-3 pilots of the 1930s. Author Ernest K. Gann, who omitted no tribulation of airline flying from his classic autobiography *Fate Is the Hunter*, passed over bad-weather range approaches almost without comment.

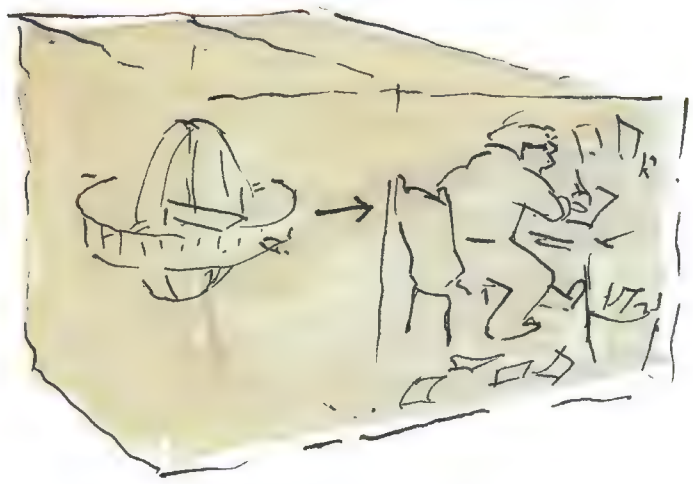
Just after World War II, a new type of four-course range, the VAR, or visual-aural range, appeared, broadcasting on static-resistant frequencies above the AM band. It was "visual" in that, in place of the sounds in the headset, a panel instrument presented the courses as a needle swinging between yellow and blue sectors. But it came too late; the four-course ranges were about to go the way of the open-cockpit biplane.

When I learned to fly in 1961, four-course ranges were still depicted on sectional charts, and I studied them before taking the written test for my instrument rating. Turned out I had wasted my time; the test bypassed the subject completely. In a dusty carton of outdated charts I find only one—a 1969 El Paso sectional—that shows a four-course range. It's at Chihuahua, Mexico.

The war had given impetus to the development of new navigation systems, as it had driven all kinds of other aeronautical tech-

A pilot approaching a four-course range station heard a Morse signal for either "A" or "N." Where the A and N overlapped, the pilot heard a continuous tone—"course." Most ranges were near an airport, and one of the four courses led to a runway.





Inertial navigation—automated dead reckoning—relies on gyroscopes and accelerometers to measure the aircraft's motion. A computer (right) integrates the data and announces where the airplane has moved to from its last announced position.

nologies. Bombers above clouds seeking targets below required some web upon which they could crawl to a given intersection. Methods had to be accurate to within a few hundred feet and resistant to jamming.

Several systems used a "master" and two or more "slave" transmitters, which created families of intersecting hyperbolic lines of position. Most of these systems were decommissioned at the end of the war, but one, Consolan (Consolidated Low or Medium Frequency Long-Range Aid to Navigation), was still broadcasting over the north Atlantic in the 1970s, and Loran still serves today (opposite). With these systems, latitude and longitude are determined from the different arrival times of sychronized signals from two or more fixed transmitters.

Long overwater flights still relied heavily on dead reckoning because celestial fixes were not always available. Dead reckoning required a knowledge of drift. Sometimes drift could be observed; optical drift meters enabled navigators to measure the angle at which objects on the ground moved past the airplane. With a layer of clouds below, however, or over

Where the Beacons Beckon

"There it is!"

We were barely off the runway at Helena, Montana, when I caught sight of the first beacon winking from the ridge ahead. The sun had set an hour ago, and the mountains stood in inky silhouette against the pale western sky.

We crept westward against a smooth, steady headwind that cut our groundspeed to 100 mph. The skyshine paled and vanished. The darkness was complete now: Black tree-cloaked mountains below us, black star-flecked sky above. From our cruising altitude, 8,500 feet, just above the highest mountaintops, we could see two or three beacons at a time, stretching out ahead of us and curving gradually to the right. The first was MacDonald Pass, then Avon; there was a gap at the sparsely lighted town of Drummond, then the chain picked up again. Five more beacons would wink into life ahead of us, spell out their identifiers in Morse code with a fainter red light, and slowly pass beneath before we emerged from the mountains at Mullan Pass, just east of Coeur d'Alene, Idaho.

The Montana airway beacons are the last survivors of a great system of more than 1,500 that once dotted the country. Initiated by the Postal Service, which realized that airmail could offer no speed

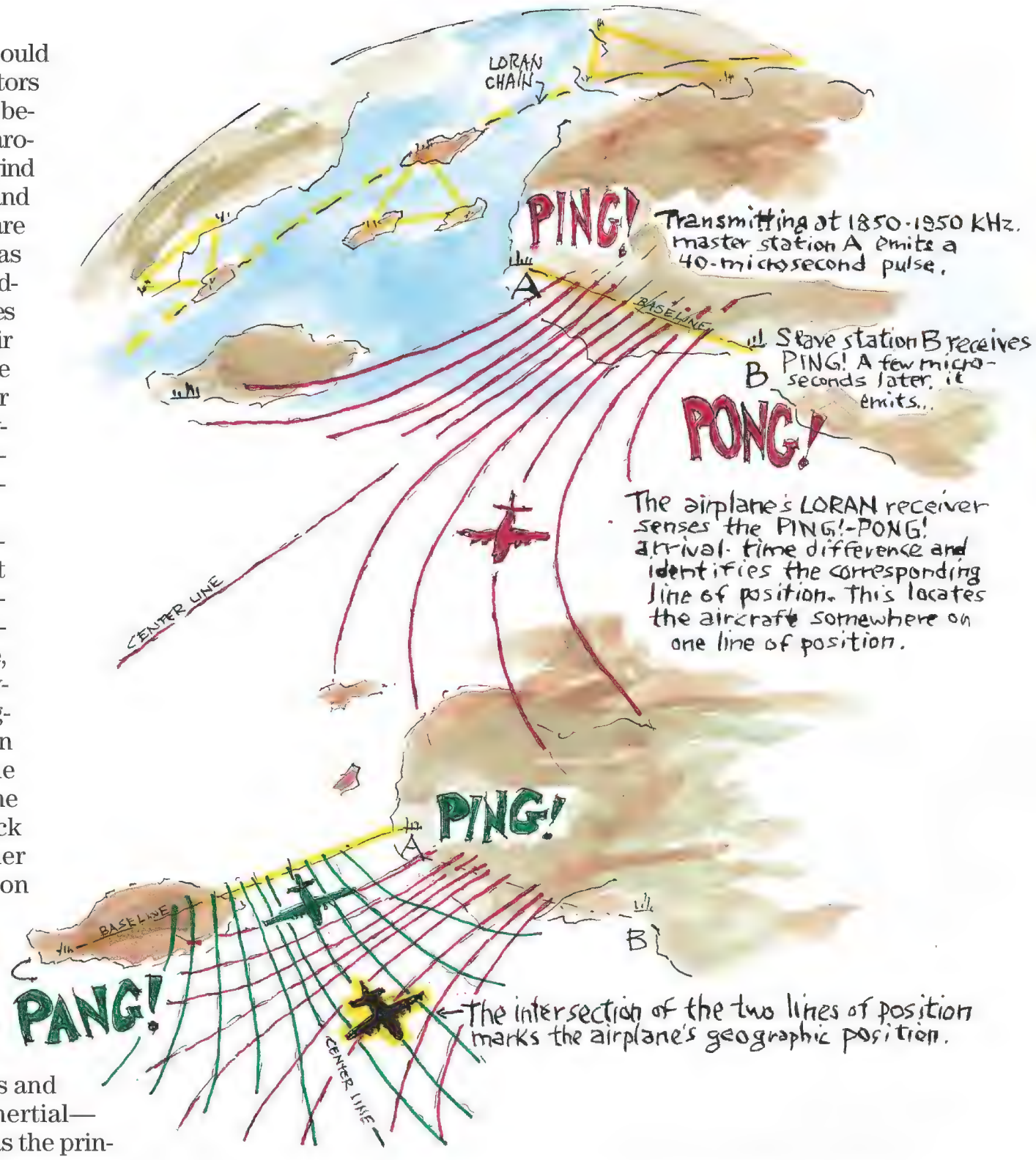
advantage if airplanes were idle during the night, the beacon system grew from a 1919 experiment with strings of bonfires to guide airmail pilots across the Great Plains into an 18,000-mile network of federal airways managed, after 1926, by the Department of Commerce. It survived into the 1970s, though by then few pilots were aware of it. When the Federal Aviation Administration decommissioned the beacons, Montana, which had 39 of them marking routes through the mountains, took over those within its borders. Ultimately, it kept 17 operating in its mountainous western half, linking Coeur d'Alene, Missoula, Helena, Great Falls, and Butte.

The French novelist Marcel Proust, writing about a midnight stroll through the streets of Paris when it was being bombarded by the Germans in World War I, describes the reassuring feeling of being watched over by a benevolent power that the defensive searchlights crisscrossing the sky gave him. I felt the same way about the beacons. The guidance of radio signals is cold and abstract, but a light on a distant mountain, winking rhythmically, emits a personal, human warmth. "This way!" it seems to say. "I am here."

—Peter Garrison

water driven by the wind, drift could not be reliably measured. Navigators turned to the known relationship between isobars—lines of equal barometric pressure—and wind. The wind blows nearly parallel to isobars, and its speed is greater where they are closer together—that is, in areas where pressure is changing rapidly. Navigators could measure changes in barometric pressure along their route by comparing their pressure altimeters with a radar altimeter that gave true height above sea level. From the rate of change of pressure, they could obtain an accurate wind component.

It was possible, merely by knowing the barometric pressures at the starting point and at the destination, to select a single heading to be flown for the entire route, although it was more usual to divide the route into shorter segments. The airplane might be blown to one side of the course or the other by varying winds along the way, but in the end the cross-track errors would cancel one another and the airplane would arrive on target. Pressure-pattern navigation, together with inertial and celestial, remained an important part of the navigator's toolkit for flights of more than 350 miles into the 1970s.



Loran, short for long-range navigation, determines latitude and longitude from the different arrival times of synchronized signals from two or more fixed transmitters.

For intercontinental airliners and for many military airplanes, inertial—automated dead reckoning—was the principal means of navigation. Gyroscopes and accelerometers measure the motions of the airplane with great precision, constantly integrating the data to determine how far it has traveled and in what direction. The equipment is extremely delicate, precise, and costly, because the allowable margins of error are so small; but new electronic motion-sensing devices, built without moving parts, may yet make inertial navigational gear commonplace.

Steadfast as Thou Art

The most intellectually challenging and aesthetically satisfying form of navigation is celestial—navigating by the stars. To locate yourself by the very framework of the universe—what could be more Godlike? Unfortunately, celestial navigation is a most complicated and cumbersome technique.

The principle, however, is simple. The positions of the sun, moon, and a number of conspicuous stars are tabulated in books called ephemerides (which, by the way, are used by astrologers as well as navigators). The "position" of a heavenly body at a given moment is the point on Earth at which it is exactly overhead—the "substellar point." Seen from any other point, it is at some angle to the vertical. The observer must be located somewhere on a "circle of position" whose radius is that same angle upon Earth's circumference, and whose center is the substellar point. Knowing approximately where he is from dead reckoning, the navigator obtains local segments of those circles for three bodies in different areas of the sky, and approximates

them on a chart with straight lines. These intersect to form a triangle that represents the observer's approximate position (see "Celestial Navigation," How Things Work, Oct./Nov. 2001).

During the 1930s and '40s, many aircraft that flew transoceanic routes had in their roofs a hemispherical plastic bubble called an astrodome. The navigator would stand with his head in the astrodome to take star sights. Since the horizon was seldom clearly visible from the air, he used a variation of the marine sextant called a bubble octant, which had a bubble level to identify the vertical. A good navigator can take the necessary sights, perform the calculations, and plot the results in 10 minutes, achieving a tolerance of five miles or so.

The astrodome was eventually replaced in pressurized airplanes by a small hole in the cockpit ceiling through which the navigator stuck a periscope; Douglas DC-8s, Boeing 707s, and even early Boeing 747s were still equipped with one. Crews found unexpected uses for the hole, from which air rushed when it was opened. Swissair DC-8 crews called it the "banana hole," because after eating a banana you could allow it to suck up the peel. U.S. Air Force C-141 crews linked oxygen hoses together, held one end to the hole, and used the other to vacuum the cockpit.

Today, celestial navigation is still the crux of the Federal Aviation Administration navigator's rating. Only three FAA examiners can administer the test, a two-day ordeal, and applicants are few. The Air Force, however, still trains celestial navigators in large numbers, and refueling aircraft are equipped with electronic star finders for the apocalyptic day that the Global Positioning System satellites fall silent.

The Global Positioning System, originally intended for military tracking, comprises 24 satellites that can pinpoint the location of anything on or near Earth to within a few feet.

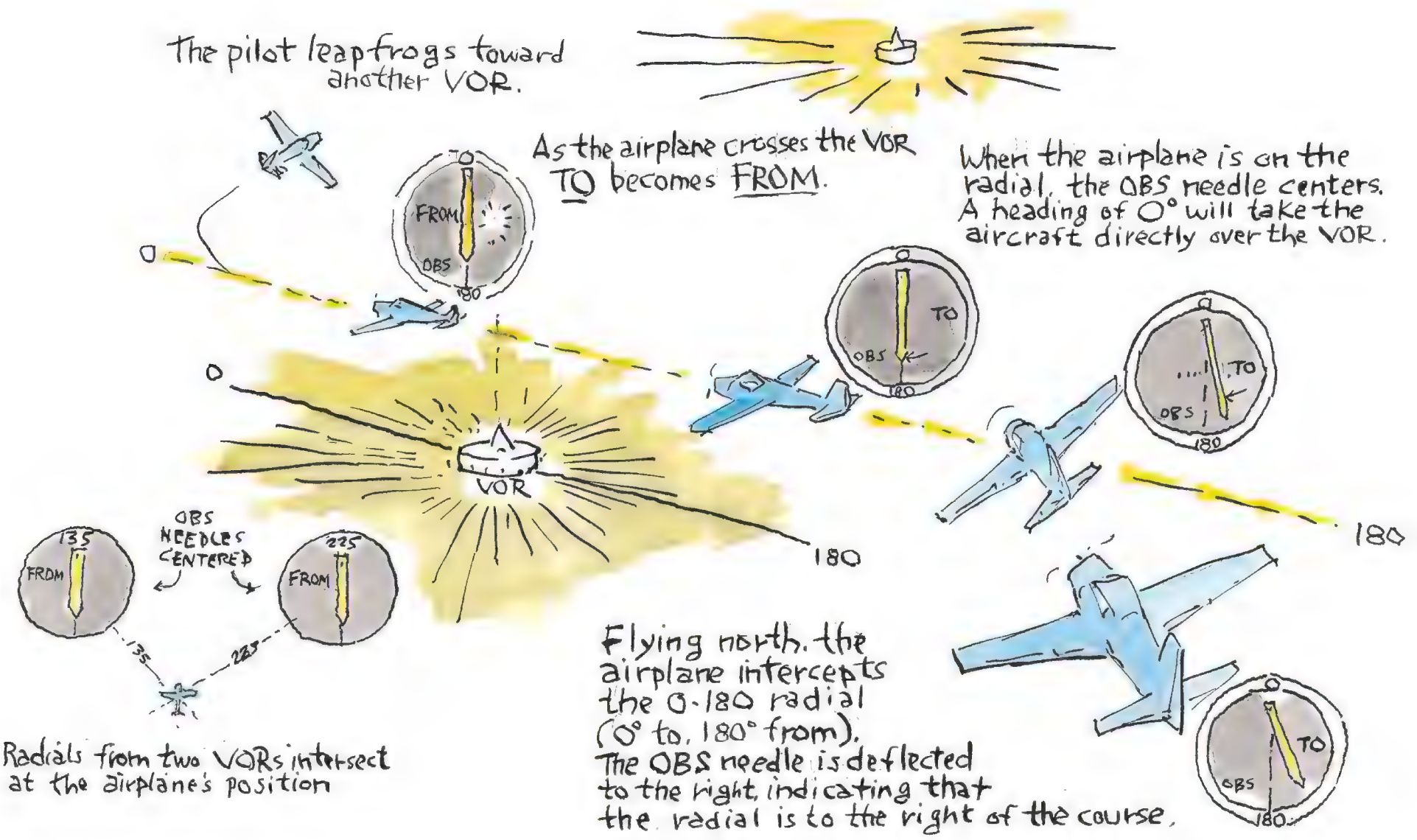
"Wink...VOR"

The acronym "VOR" originally stood for visual omnidirectional range, to distinguish such ranges from the old aural four-course variety. As the original significance of "visual" faded from the consciousness of new generations of pilots, the "V" was said to stand for "very high frequency," and that is the explanation usually given today.

VORs were a major advance. They were much more precise than non-directional beacons had ever been, and immune to most atmospheric static and distortion. But their presentation on the instrument panel was somewhat unintuitive to minds adapted to the automatic direction finder. The instrument was called an OBS, for omni-range bearing selector. Originally, most were colored blue and yellow, in imitation of the VAR four-course range displays. A needle swung from side to side as you turned a knob to rotate a compass rose. When the needle was centered, the position of the compass rose told you your bearing to or from the station. A little triangular pointer or "flag" distinguished between "to" and "from" bearings.

Unlike the NDBs, which pointed a finger, human-like, at the transmitting station ("It's over there!"), VORs gave you a number, an abstraction that required you to refer to a map to convert the number to a line of position, called a radial. Most aircraft had two VORs, and an exact position could be obtained by the intersection of two radials at a reasonably large angle to each other or, alternatively, by a radial and a distance provided by a radio ranging gadget called distance measuring equipment, or DME.

By the mid-1950s the country was thickly dotted with VOR and DME transmitters—low circular structures, each with a slender truncated cone rising from the center. Dead reckoning sank into disuse, surviving only in questions on the private pilot written test, as pilots came to depend on VORs as step-



ping stones from one place to another.

VORs made it unnecessary to monitor the wind. With non-directional beacons, if the pilot did not include drift in his heading, a crosswind would push the airplane off track. The automatic direction finder needle would swing progressively to the side as the pilot, continually adjusting his heading, flew an unintentional curved line toward the station. VOR radials are fixed tracks in space; a pilot automatically compensates for wind drift if he merely keeps the OBS needle centered.

One of the unintended side effects of the VOR network was to superimpose upon the familiar map of the United States one that accorded to little-known places like Wink, Texas, or Hector, California, the same familiarity as St. Louis and Indianapolis. It drilled their names into the consciousness of pilots who, droning along, often at night, over a featureless landscape, fastened their attention upon, for lack of anything better, a Morse code identifier and a faint, scratchy tenor intoning, over and over, "Wink...VOR..."

I Once Was Lost, But Now Am Found

Each advance in navigational technique brought an improvement in accuracy, reliability, or ease of use. Each was in one way or another a simplification, but it also required new learning and new insights from its users. And then came GPS, the satellite-based system, originally intended for military tracking and targeting, that identified the location of anything on or near Earth within a few feet.

GPS changed everything. It was GPS—or rather the boundless varieties of digital processing of raw GPS data—that brought navigation to maturity, and the great historical traditions of navigation to their knees. A drug irresistible to even the fiercest Luddite, GPS at one infantalizes and deifies us. With GPS there are no landmarks, no beacons, no airways, except as relics of earlier times. There is only the surface of the planet. GPS makes skill, intuition, and judgment unnecessary. Navigation, that great and noble art, whose traditions reach back into the darkness of prehistory, has degenerated into a computer game. Orientation, sense of direction, dead reckoning, line of position, pilotage, weather sense, drift, heading, track, course, VOR, NDB, precession, magnetic variation, estimation, latitude, longitude, azimuth, elevation, lost, found—relics all.

Very-high-frequency omnidirectional ranges, or VORs, transmit a signal at a specific frequency in all directions, like spokes on a wheel. The spokes, called radials, are compass headings to or from the transmitter. An omni-range bearing selector, or OBS, in the cockpit has a knob the pilot turns to rotate a compass rose. When the needle centers, the position of the compass rose tells him his bearing to or from the station.


GOING

UP?

The hopes of space elevator proponents rise higher than their hardware.

by Michael Milstein
Photographs by Scott Highton

STEVEN JONES CROUCHED IN A CALIFORNIA PARKING LOT, hoping to pioneer the next great stride into space. The clean-cut, 22-year-old senior in engineering at the University of British Columbia was tinkering with a robotic contraption he and fellow students built out of solar cells, motors, hot-tub tubing, and pieces of a purple bicycle.

Cost: about $1,000. Mission: Climb a 220-foot blue strap dangling from a crane at NASA's Ames Research Center, powered by only a 10,000-watt searchlight aimed at the contraption's solar panel. Reaching the top in less than three minutes would win Jones and his partners $50,000 in a NASA competition, plus a permanent place in the lore of the far-out, far-off, and far-fetched concept known as the space elevator.

The idea remains little more than a dream, at least for now. But contest promoters boasted that Jones and his competitors possessed nothing less than prototypes of a dream machine that will one day motor us into orbit along superstrong cables as easily as today's trains carry us to the next town.

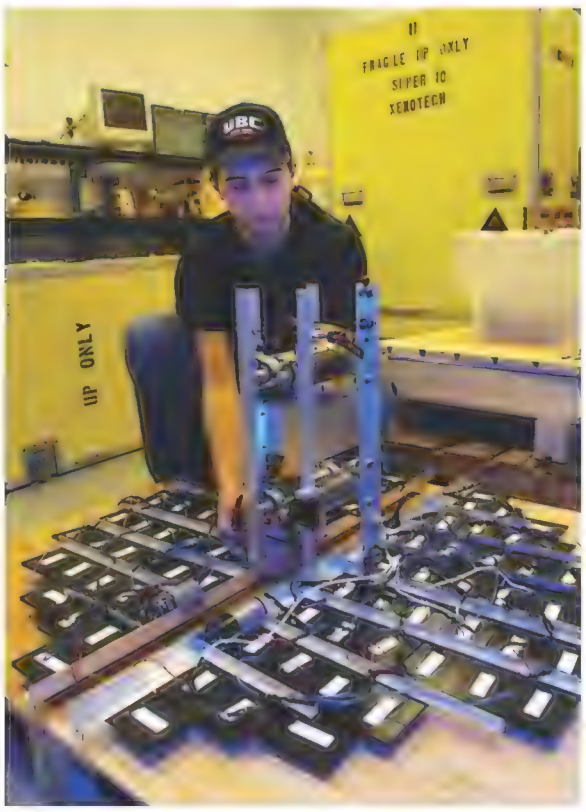
The competition offered a glimpse into everything the dream of the space elevator has going for it and against it: on the one hand, energy, ingenuity, and confidence that it is possible, and on the other, monumental technical obstacles and unforeseen mechanical breakdowns that make it seem unattainable.

As Jones' robot, Snow Star One, inched off the launch platform, the thin crowd of onlookers cheered. But the robot was sluggish. The corrugated hot-tub hoses, clamped onto either side of the strap for grip, kept slipping. After a few feet the climber's solar cells melted in the searchlight's beam, black plastic dripping from them like icicles.

Snow Star One struggled to a stop.

"That robot was pretty slow," a young spectator informed Jones as he disassembled it, rushing to catch a flight home to finish his midterms.

By the contest's end, none of the robot climbers came close to claiming the $50,000 prize; some didn't move at all, and only two covered any distance on light power. The same slowness could be said to describe the overall progress



Steven Jones works on his prototype for a space elevator car, Snow Star One, which beat most contestants by reaching a less-than-stellar height of 20 feet (opposite).

Ambition and wheelchair parts were not enough to garner team Space Miner any prize money. Their climber didn't move at all.

in the development of the space elevator itself.

In fact, NASA backed the contest only to encourage precursor space technology. "We have no plans to build a space elevator," says Brant Sponberg, manager of NASA's Centennial Challenges program, which offers cash prizes to fuel innovation in the same vein as the X Prize. The idea is to attract interest in space projects from inventors beyond the usual circle of big contractors that routinely seek NASA funding. "But when you take a space elevator apart into all of its pieces, there are a lot of things we're interested in," Sponberg adds. "The basic physics are practical, but the material—not yet. That makes it a hard sell for the agency right now."

But belief is growing that a space elevator may be in our future. A NASA report completed in 2000 predicted a space elevator would become practical in the second half of this century. Optimists say a functioning system is perhaps no more than a few decades away, if someone savvy in the private sector decides to attempt one.

A couple of companies, backed by venture capital, are already investing in the basics and have scoped out the climber robots in California for ideas. Believers say that as crazy as the space elevator sounds, it's even crazier to not pursue what could be the cheapest and most reliable route into space.

"We need to sort of open up and use our imagination and creativity," says Robert Cassanova, director of the NASA Institute for Advanced Concepts in Atlanta, which has paid for some initial studies on the idea. "We need to start with a new sheet of paper and come up with some new ideas. That's sort of the story of the space elevator. It's one of these really big ideas. Finally people are starting to take a serious look at it."

Although the gadgets that showed up in California are as far from the real thing as a magnifying glass is from the Hubble Space Telescope, here's how the finished concept would work: A floating platform of some kind, perhaps a big ship, would station itself somewhere along the equator. From there a ribbon made of a material stronger than diamonds would stretch about 62,000 miles into space.

The end of the cable would carry a counterweight of some kind, maybe rockets or other left over equipment from construction. The fulcrum of the elevator cable mass would have to be positioned at 23,000 miles— at geosynchronous orbit, where satellites constantly tower over the same point on the planet. But for its center of gravity to be positioned at geosynchronous orbit, the far end of the cable must extend way beyond that point. Like a teeter-totter that sticks out to either side of the balancing point, the cable must extend 62,000 miles, according to the most prominent approach being considered.

Earth's rotation would whirl the enormous wobbly tower, like a tennis ball on the end of a string. The momentum of the spin would keep the cable taut, and roomy elevator cars would shuttle people and cargo between stations along the line.

The elevator cars would be powered by a laser on the ground—much like the searchlight in the California parking lot—beaming energy to collector panels on each car.

Daily elevator departures would make expensive and risky rocket launches obsolete. Costs of lofting satellites could fall substantially, making communications and everything else that depends on them far cheaper. With many more people able to afford it,

space tourism would become truly practical. Or so elevator champions, like Bradley Edwards, believe.

Edwards attended the elevator challenge not to compete but to cheerlead. He first got curious about the space elevator as a physicist at Los Alamos National Laboratories in New Mexico after hearing the naysayers proclaim it would never work. The technology conronts many dangers, and Edwards has heard them all. What happens, for example, if the elevator cable collides with something in orbit? About 100,000 pieces of debris big enough to sever a cable speed around Earth. Space junk is so plentiful that a piece could slice through the cable roughly every 250 days. Such a catastrophe would leave anything above the break careening through space, and anything lower falling in a fiery reentry toward the planet.

Edwards has a plan to avoid this. First, the cable would be designed to withstand impacts. Instead of a single strand, the cord would consist of a flat ribbon of nanotube fibers lined up side by side and reinforced at intervals by horizontal strips of high-strength tape. If a speeding meteorite cut through a few fibers, the tape above and below the break would hold the rest tight and shift the load onto adjoining fibers. Also, the flat bundle of fibers would have a slight curve to it, so a small meteorite that hit it sideways would not slash through all the fibers.

Earth's rotation would whirl the enormous wobbly tower like a tennis ball on the end of a string. The momentum of the spin would keep the cable taut, and elevator cars would shuttle people and cargo between stations along the line.

A robust system to track orbiting debris, Edwards notes, would spot anything endangering the elevator and alert the ship or floating platform at the base of the cable to steer clear. A mile or two of movement ought to be enough to dodge the dangers, Edwards estimates.

If the materials and money are available, advocates argue that no law of physics prevents an elevator from working. Then again, you could have said the same about building a robot able to climb a rope.

Some of the machines that competed in the challenge resembled assemblies of Erector Sets, while others looked like they could stop a tank. Brian Pierce and his teammates spent more than a year constructing their climber from an extra wheelchair frame that team leader Vincent Lopresti had in his closet in Texas. They sold T-shirts and coffee mugs to raise money for parts and hit up companies such as Dremel for tools and Sunrise Medical, a medical supply company, for the solar cells. The team scavenged the motor from a kid's Mongoose scooter, and tension springs from a Chevy carburetor.

For Lopresti, 40, the competition signaled that space is finally open to the public, and he wanted in. A software-designer-turned-engineer who thinks his home near Dallas would make a good spaceport, he grew so obsessed with the space elevator he couldn't think about much else. He turned designs over and over in his head. "It's almost like a kid in a candy store; there are so many different options," he said. "I have all kinds of junk in my house,

Riding a 10,000-watt beam requires the creative use of mirrors. Left: The Utah-based Centaurus Aerospace team adjusts a Fresnel lens. Right: Team SPECO aims the light.

and it just all started falling together."

Their climber evolved into a kind of sideways wheelchair with a motor on one side and a solar panel as a counterbalance on the other. Lopresti foresees an extraterrestrial gold rush as a space elevator opens the door to mining moons and planets and collecting and recycling satellites that have gone kaput.

"I'm going to do what I can to make sure that happens," said Lopresti, zipping around in his wheelchair at an industrial park in Mountain View, California, where teams tuned up their climbers before the competition. It was tense as competitors sized up opponents they'd face the next day. Some worked through the night, struggling with last-minute fixes.

The trouble they all ran into was one that has always dogged spacefarers: Lifting even a pretty small craft takes a lot of power. That's especially true when relying on solar panels, which capture only a small slice of energy from light falling on them. Even the industrial searchlight provided for the contest, as bright as it was, did not generate much juice.

Lopresti's climber, Space Miner, wouldn't budge. "We cut off all the extra things, but it's still 70 freaking pounds," an exasperated Pierce declared.

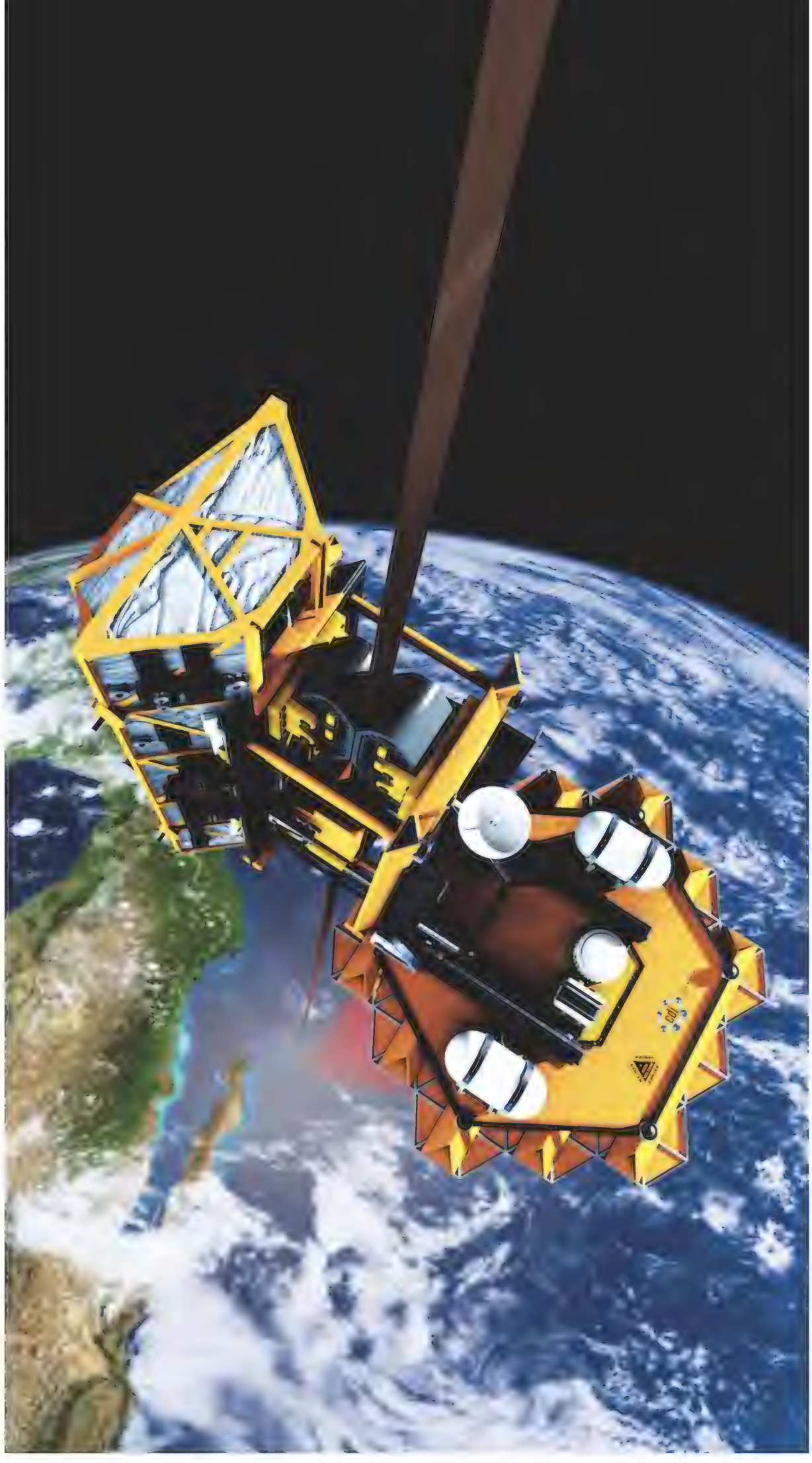
Other teams tried novel ways to wring power from the light. Engineer Matthew Abrams arrived from Maryland with his climber in suitcases bearing duct-tape labels that said "Robot parts—fragile." When he got it together, a reflective dome focused light on a water-filled canister.

The plan was for the water to heat up, producing pressure to drive a piston that would yank the climber up the strap. But the water hit only 150 degrees instead of the 300-plus Abrams needed.

"That's all?" Abrams asked in disbelief, watching a thermometer tick off the degrees much too slowly. "We're screwed."

None of it discouraged Bradley Edwards. He has the cost penciled out at around $10 billion, the price of a few space shuttles. It would take about 15 years to build, he said, once we set our minds to it. "It's definitely doable. The question is just: When is it going to be built and who's going to build it?"

That's why he started his Seattle-based company, X-Tech Projects—to help propel the space elevator toward reality. Edwards, who has a boyish look and wry sense of humor, knows that developing an elevator will require a bit of showmanship. He's talking with



THE SPACE ELEVATOR VISUALIZATION GROUP

Coming in 2080? A space elevator could carry into orbit 15-ton payloads, which would accelerate along a paper-thin ribbon extending into space. Right: The metal, mirrors, and imagination behind today's highest climber; the University of Saskatchewan team's contraption reached 40 feet.

Las Vegas casinos about building mock space elevators that would be part amusement-park ride, part teaching tool, and part public relations gimmick. Tourists would hop in an elevator that, simulating the real space elevator he envisions, would whisk them to a deck where they could see prototype elevators and take in simulations of the scenery of space.

If the real thing comes out anything like Edwards' dream, it will be quite a ride. Elevators lifting off for space would accelerate upward as they escaped Earth's gravity, but the trip to orbit would take about a week. Passengers might dine and sleep, as on a modern cruise ship, as they grew lighter and lighter until they enjoyed the effects of microgravity.

The fantasy of such a ride bounced around science fiction circles for decades and was popularized by Arthur C. Clarke in his 1978 novel, *Fountains of Paradise*. But in the 1990s a Japanese researcher took the concept out of the realm of science fiction when he developed the carbon nanotube, a tiny interlocking lattice of carbon atoms that has taken on such legendary status it's hard to tell where reality ends and myth begins.

Nanotubes are, without a doubt, unbelievably light and strong—at least 50 times tougher than steel and harder than a diamond. A sewing thread made of them could easily dangle a limousine. The drawback is that the longest nanotubes produced so far are no more than an inch or two. Space elevator boosters, ever the optimists, point out that that's far longer than only a few years ago.

But it's also far shorter than the tens of thousands of miles they need to cover. Elevator proponents now hang their hopes on research that will eventually blend nanotubes with materials like high-strength plastic and spin the mix into long fibers as strong as the nanotubes they contain.

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"The big issue is how do you put them together so you get their strength in the composite," says Rodney Andrews, a nanotube researcher at the University of Kentucky's Center for Applied Energy Research.

Not all hopes are pegged on government funding. A Seattle startup company, LiftPort Group, is gearing up its own nanotube factory to tap into commercial demand while also exploring how nanotubes might serve a space elevator. "A lot of people think: If we just have nanotubes, we start throwing this thing together," says LiftPort president Michael Laine. "But we still have a lot to learn. We have to build a lot of bad stuff before we start building the good stuff."

LiftPort built its own ribbon-climbing robot and got clearance from the Federal Aviation Administration to run it up the tether of a 12-foot balloon over the sagebrush of eastern Washington in September. Laine sees profit there too: LiftPort hopes to market the robots for aerial surveillance, generating income to develop better robots and space elevator designs.

"We don't know what we're going to get out of a space elevator," says Laine, "but I'm damn sure it's going to be profitable."

One evening during the competition, about 75 people gathered in a big garage where they sipped wine and waited for a string to break. It was the second half of the NASA-sponsored cash challenge, a test to see if anyone could come up with material stronger and lighter than what's available off the shelf today.

Every entry had to be very lightweight, just like the space elevator cable, with its six feet weighing less than a penny. Contestants had to beat a "house tether" made of the best off-the-shelf material. The house tether had a built-in advantage: It was allowed to weigh 50 percent more than any of the entries. If any could beat the house, the team would win $50,000 and become the frontrunner in a similar competition planned for 2006.

The outcome might hint at whether the elevator can be built within our lifetimes. Ben Shelef, co-founder of the Spaceward Foundation, a non-profit organization that ran the event with NASA money and touts space elevators to schoolchildren and engineers with equal fervor, has a timeline worked out. If the winner of each year's tether competition proves 50 percent stronger than the year before, the competition should lead by 2013 to material tough enough to string up the space elevator.

But only four people entered the strong string contest, and no one brought a nanotube. The house tether beat all comers: The strongest competitor broke under about 1,250 pounds of stress.

Since no one won the $50,000, Shelef's schedule was set back at least a year, and all the prize money will roll into next year's contest.

Tell all the engineers you know. There's $400,000 available all this year for the owner of a robot climber or a length of stronger-than-imaginable string. Easy money?

Fire and Ice

A WRECKED BOMBER IN RUSSIA MEMORIALIZES A WORLD WAR II BATTLE FOR THE NORTH PACIFIC.

by Ralph Wetterhahn

Adapted from the book The Last Flight of Bomber 31 *by Ralph Wetterhahn,*

Navy fliers from the Casco airfield on the island of Attu played a forgotten role in World War II. The U.S. Coast Guard still flies to the island, amid ruins of war (right).

LEFT: NATIONAL ARCHIVES; ABOVE: RALPH WETTERHAHN

In 2000 James Connell, a U.S. Embassy officer in Moscow, worked his way up the slope of an extinct volcano on Russia's far eastern Kamchatka peninsula. The former Navy captain carefully stepped around .50-caliber rounds and an unexploded 500-pound bomb, each marked with yellow warning flags, and headed toward the flattened tail of a wrecked aircraft.

Connell was part of a team from the U.S. Department of Defense's Prisoner of War/Missing Personnel Affairs Office seeking the ruined airplane. Acting on information from a Russian researcher who discovered in a 1962 document a reference to a crashed World War II airplane, the team was deployed to identify the airplane and determine if any remains of U.S. servicemen could be recovered.

Picking through the crash site, Connell lifted the left vertical stabilizer, found the number 34641, and checked it against his list of missing aircraft. The team matched the number to a Navy PV-1 Ventura bomber that during World War II had been stationed 750 miles east, on Attu Island in the Aleutians, a curved chain that extends from Alaska toward Japan.

The discovery of the Ventura, 56 years after the bomber's seven crewmen had gone missing, finally gave surviving family members some knowledge about how the men had died. It also provides a dramatic reminder of World War II battles that today may not have the familiar ring of "Midway" or "Leyte" but nevertheless played a pivotal role in winning the war in the Pacific.

Just after midnight on March 25, 1944, U.S. Navy Lieutenant Walt S. Whitman and his copilot, Lieutenant John W. Hanlon, looked over their bomb-laden PV-1 Ventura, bureau number 34641. The snow crunched underfoot as they inspected their warplane. Relentless wind blew damp, cold air through even the best parkas, making the pre-takeoff check hard on Whitman, who hailed from sunny Miami. In the air it was worse; the pilots and five crewmen greased their faces to prevent frostbite.

Pilots based in Attu, a flyspeck island at the end of the Aleutians chain, flew long sorties against Japanese installations in the Kurile Islands. The elements and the enemy claimed pilots' lives. By the end of this day, nearly a dozen men would lose their lives to both.

As Whitman was warming his engines, squadron mate Lieutenant James H. Moore's Ventura lumbered onto the runway end and shut down beside a fuel truck. After topping off the tanks, Moore restarted the engines and released the brakes. His props churned loose snow into a billowing cloud as the PV-1 swept down the 4,500-foot runway.

Instead of climbing, the airplane stayed level. Wings heavy with ice, the Ventura hit the surface of Massacre Bay, became airborne again, then plunged into the frigid surface. "Water was coming in," recalls Moore from his home in Lake City, Florida. "I had flight boots on, and one was jammed under the rudder [pedal]. I pulled my foot out of the boot without unzipping it. I surfaced and started yelling, 'Let's get to the life raft!' "

MAP: JUAN THOMASSIE

lands before more damage could be done. (In fact, the raid had been launched from an aircraft carrier.)

Between June 1942 and June 1943, the Japanese occupied and fought to hold Attu and Kiska Islands. Both sides suffered heavy losses. In the battle for Attu alone, over 500 U.S. troops were killed and 1,200 wounded.

On top of Attu's Point Able today, mortar rounds and spent shell casings from both American and Japanese rifles litter the foggy landscape. Rusted hulks of trucks and tracked vehicles from the 1940s dot the nearly treeless island. On the beach of Holtz Bay to the north, a 14-cylinder Sakae 12 engine from an A6M2-N Rufe fighter serves


NATIONAL ARCHIVES

A fleet of PV-1s race over the Bering Sea toward Japan. Jettisoning into the water meant death in 10 minutes. On land, it took longer.

Only three of the seven men made it. Everyone aft of the cockpit was killed. Whitman and his crew must have watched from the runway as the airplane was consumed in flames, wondering if their mission would be scrubbed. Instead, they received word to fly.

When it was Whitman's turn to take off, 50 minutes later than scheduled, their PV-1 rumbled into the air and skimmed above the rescue boats, still circling where Moore had gone down.

The long delay getting airborne would place Whitman and his crew over the target at first light, something that had not been tried since a spate of disastrous daylight raids the year before.

It's not known why, but the pilot flew beyond his target and reversed course. Whitman's final transmission to his base in Attu was "Down, down!" The Ventura and its pilots disappeared without another word.

Also on board, and presumed lost, were aviation metalsmith/navigator Donald G. Lewallen of Omaha, Nebraska, aviation radioman Samuel L. Crown Jr. of Columbus, Ohio, aviation machinist's mate Clarence C. Fridley of Manhattan, Montana, aviation ordnanceman James S. Palko from Superior, Wisconsin, and aerographer Jack J. Parlier from Decatur, Illinois, who was on his first combat mission.

Whitman and his crew were said to be riders on the Empire Express, the bombing route from the Aleutians to the Japanese strongholds in the northern fringe of their empire. The Empire Express' contribution to World War II has slipped from the mainstream idea of how the conflict was fought and won.

Few remember that during World War II the Japanese invaded and held several of the Aleutian Islands, part of Alaska. The Japanese high command, suspecting that the April 18, 1942 raid on Tokyo by Lieutenant Colonel James Doolittle's B-25s had originated in the Aleutians, decided to capture the islands before more damage could be done. (In fact, the raid had been launched from an aircraft carrier.)

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With the Japanese driven from the Aleutians, the stage was set for the U.S. military to take the fight directly to enemy territory. The targets were the islands Paramushiro and Shimushu, both in the Kuriles.

The Japanese had taken over the pair from Russia following the 1875 Treaty of St. Petersburg. By the start of World War II, the Japanese had settled them in large numbers, making the islands part of the Japanese homeland.

Being close to Siberia, these northernmost and treeless islands experience harsh winters, more severe even

than those in the Aleutians. Soldiers lived in half-subterranean barracks, dug into pits with roofs reaching ground level to better withstand high winds and heavy snow. Inside, men slept on bunks above dirt or wooden floors and used potbelly stoves for heat and cooking. They waited for U.S. airplanes to arrive, anti-aircraft batteries and Oscar fighters at the ready.

After the liberation of Attu, U.S. forces began creating airfields from which they could attack Japan. It was not a glamorous posting: The island is located about 1,500 miles from mainland Alaska. Its moist soil is covered in thick moss and lichen, giving the ground an elastic, trampoline-like quality. But the terrain is honeycombed with hidden sinkholes that can snap the leg of an unwary hiker.

Attu's violent history echoes in the names of its locales: Massacre Bay, Murder Point, Mount Terrible. From the Russian fur traders' slaughter of native Aleuts to the costly battles of World War II, the island has been witness to more than its share of calamity.

The Venturas were not deployed to the Aleutians until early 1943. Living in hastily constructed Quonset huts that sprang up later that year all over the Casco Bay area, the air wing began flying patrols over the Bering Sea. Except for engaging Japanese shipping involved in the evacuation of Kiska, the patrols were long and monotonous.

All would change, however, with a single experimental flight. On November 16, 1943, Lieutenant H.K. Mantius received permission to fly a Ventura to within 30 miles of the northern Kuriles. He was hoping to prove that the Venturas stationed on Attu could reach Japan, both to spy on and attack the enemy. Airborne for nine hours and 35 minutes, Mantius landed with 40 minutes' worth of fuel remaining. The point was proven: The airplanes and the pilots were ready. All they needed was a commander to give a green light.

Commodore Leslie E. Gehres commanded Fleet Air Wing Four in the Aleutians from his lavishly appointed quarters on what would be called Sweat Hill on Attu. Cutting a tall, imposing figure, he was referred to as the Navy's Hermann Goering by many of his subordinates because of his physical resemblance to the German air marshal and the penchant for luxury the two men shared.

The latter was evident in Gehres' personal PBY, outfitted with an easy chair, and the construction of a barn on Attu for a cow he had shipped from Seattle so he could have fresh milk.

A tough taskmaster who had risen from the enlisted ranks, Gehres earned a reputation as an aggressively creative commander. He was particularly interested in taking the war to the Japanese.

Navy headquarters in Honolulu wanted photographic intelligence of Japanese activity in the Kuriles. With the Battle of Midway won, Pacific Command's planning was fixed on the emperor's homeland.

Gehres proposed a program that would not only provide the Navy with the photographs it needed, but also damage the enemy.

The Lockheed PV-1 Ventura was a twin-engine patrol-bomber. Its Pratt & Whitney R-2800 engines generated 2,000 horsepower, which pushed the airplane to a maximum indicated airspeed of 312 mph while flying low to the ground, considered quite speedy at the time.

Whitman and his crew must have watched from the runway as the **AIRPLANE WAS CONSUMED IN FLAMES,** *wondering if their mission would be scrubbed.* **INSTEAD, THEY RECEIVED WORD TO FLY.** *Their PV-1 rumbled into the air and skimmed above* **THE RESCUE BOATS,** *still circling.*

With two (later five) .50-caliber Browning machine guns in the nose, two more in the top turret, and two .30-caliber Brownings under the tail, the PV-1 was a formidable opponent to Japanese fighters.

The ambitious Navy fliers relied on their skill, their airplanes, and their guns to stay alive. The days of the boring patrols were over. Missions out of Attu became anything but routine.

Since Japanese targets were well guarded, Fleet Air Wing Four scheduled its missions only at night. The Navy did not want to repeat a deadly lesson learned by the Army Air Forces.

On September 11, 1943, 12 B-25s and

The wreckage of a Japanese fighter, embedded on Attu, is one of the few reminders of the island's occupation during the war.

RALPH WETTERHAHN

NATIONAL ARCHIVES (2)

Japanese gunners scan for inbound aircraft while dug into the snow of Shimushu. They were seeking targets like Walt Whitman's PV-1 (right, taking off from an Aleutian airstrip). That airplane remained lost in Russia for 56 years.

eight B-24s made a foray over Shimushu. Emboldened by the success of an earlier high-altitude raid on the Kuriles, the bombers expected to again have the element of surprise.

But this time the Japanese were ready with searchlights, sound detectors, and 25-mm anti-aircraft batteries. A radar unit was guarding Shimushu's east coast, and picket boats cruised off the coastline.

The inbound aircraft were detected and Japanese fighters took to the air. By day's end, more than half of the U.S. force had been shot down or crippled and forced to land in Siberia.

One battle-damaged B-25 returned to base only to crash-land; all but two crew members were killed. Twelve of the 20 airplanes were lost. The Army, doubting the wisdom of continuing strikes against the now well-defended Kuriles, withdrew its airplanes to fight in the South Pacific.

The Navy adhered to the restriction on daytime missions until June 11, 1944. That day, Lieutenant John P. Vivian flew a mission that changed the way the Empire Express operated.

Because the night bombers needed decent weather to find their targets in the dark, an airplane was allowed to routinely launch in sunlight to scout out conditions. Taking advantage of exceptional visibility, Vivian pressed on to spy on Shimushu and noticed with dismay that Miyoshino airfield was crowded with Mitsubishi Betty torpedo bombers.

These airplanes posed a major risk to a U.S. task force operating in the area without the protection of an aircraft carrier. A mission to destroy the air base was hastily arranged for the day after Vivian spotted the bombers.

Because its targets were precise, the mission had to be carried out in daylight. Six PV-1s swept in and demolished the Japanese bombers where they sat, with no American losses. The success convinced the leadership that daylight missions were more effective, while adding only limited risk.

The detection screen that snared the Army Air Forces was even more effective in the heyday of the Empire Express flights. To get under the improved Japanese radar, the PV-1s approached going full bore, scant feet above the swells. The first warning to the Japanese defenders that the base was about to be attacked

The PV-1s approached going full bore, scant feet above the swells. THE FIRST WARNING TO THE JAPANESE DEFENDERS that the base was about to be attacked was often the NOISE THEY MADE STREAKING OVER THE BEACHES. Before fighters could scramble, THE VENTURAS WERE GONE.

RALPH WETTERHAHN (2)

Numbers on a vertical stabilizer (above) identify the bomber found in Russia. A search crew (right) unloads gear from an Mi-2 at the site.

Tricking out the Ventura for Increased Range

To make Empire Express runs, crews pushed the PV-1 Ventura well beyond its predicted abilities. Because it had to fly across the frigid Bering Sea, the issues of fuel and range were critical.

For the trip to the Kuriles, ground crews fitted a 280-gallon fuel tank in the aft section of the bomb bay. Additional fuselage fuel tanks were also installed. As a result, the Venturas routinely flew 3,000 pounds over Lockheed's recommended maximum gross weight, and takeoffs became hazardous events.

Ironically, even with so much extra fuel, the PV-1 crews still had to be very conscious of how fast they were consuming gas. Lockheed recommended cruising at 145 knots (165 mph) but had not tested the Ventura with the weight the Army Air Force crews added. Improvisation became the order of the day.

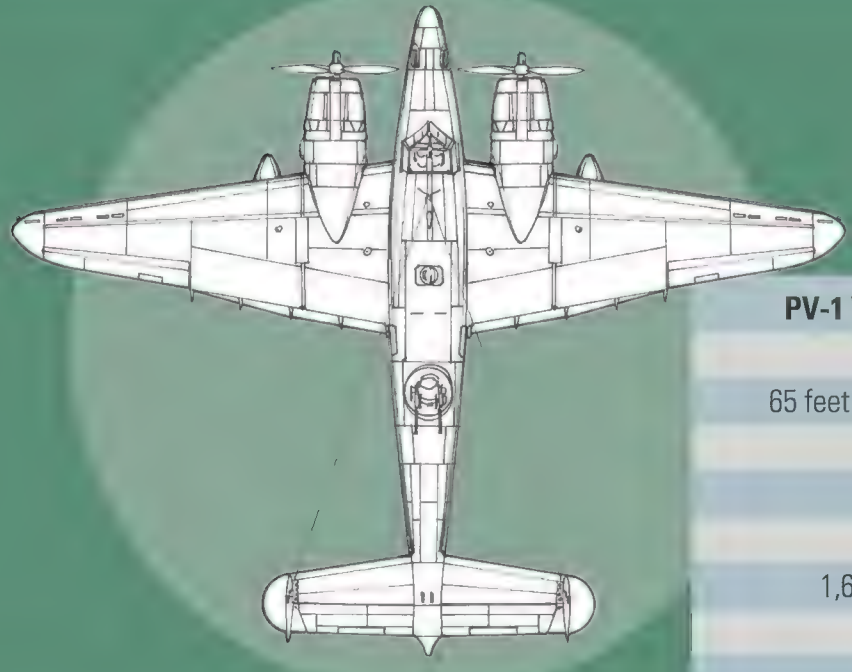
The Navy developed a "How goes it" curve for the pilots—essentially a graph of time-distance over remaining fuel. Pilots were required to remain above the curve at all times; if they didn't, they had to turn back. Some airplanes could not keep to the curve and were dubbed "gas-burners." When there weren't enough airplanes available, these known losers were called into action.

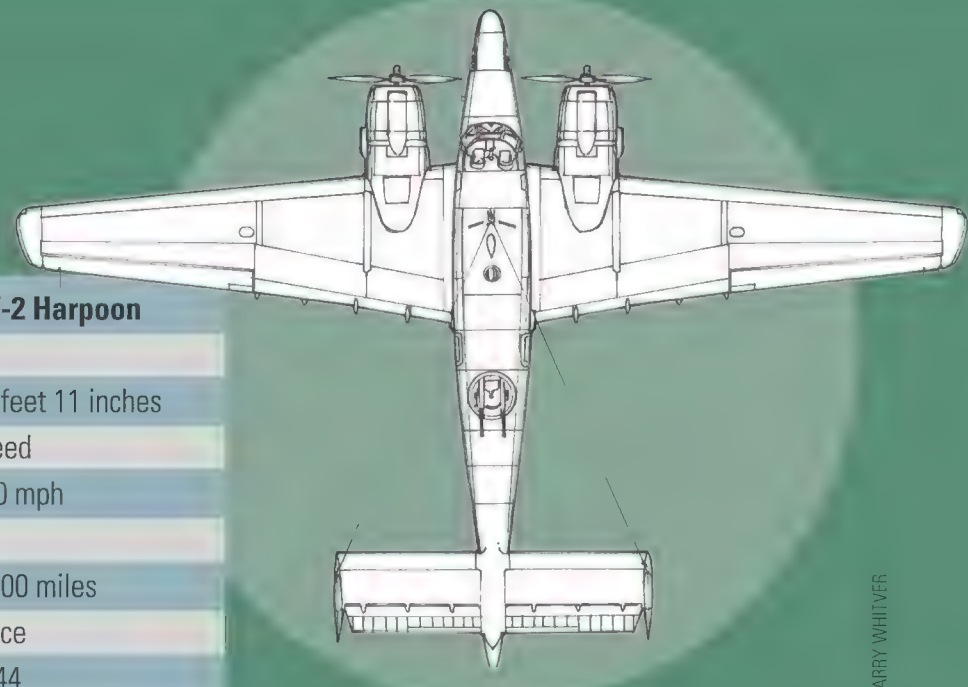
During Patrol Bombing Squadron 135's second tour on Attu, one pilot stumbled onto a way to increase range. Lieutenant J.F. Rumford's crew was assigned to fly a mission in a known gas-burner. Since Rumford assumed he would be turned back anyway, he decided to quickly bust the curve and head home fast—at about 190 mph. Amazingly, he stayed above the curve all the way to the target and returned with more fuel than anyone else. By this stroke of luck and further experimentation, the Navy discovered that the Ventura pilots were flying too slowly to conserve the most fuel.

The Navy and Lockheed recommended pilots fly at 160 mph to maximize range. But when the gross weight requirement of the PV-1 exceeded the original design, pilots did not factor in the extra pounds. When fully loaded, the optimum cruise speed was 30 mph higher than what Lockheed recommended. During the early portion of the mission, the Venturas, laden with bombs and fuel, were wasting a lot of gas.

Even with these trial-and-error fixes, the PV-1 remained a flawed tool in the war waged over the long distances of the Arctic theater. To remedy these weaknesses, the Navy created its replacement, the PV-2 Harpoon.

The new fighter-bomber featured the same general configuration, but had fuel tanks installed within its outer wing panels and a longer wingspan, increasing range and safety.





PV-1 Ventura	PV-2 Harpoon
Wing Span	
65 feet 6 inches	75 feet 11 inches
Maximum speed	
300 mph	280 mph
Range	
1,600 miles	1,800 miles
Entered Service	
1940	1944

HARRY WHITVER

was often the noise the Venturas made streaking over the beaches. Before fighters could scramble, the PVs were gone.

Trying to run down a departing Ventura while it was going flat-out at wave-top level was suicidal. A Japanese fighter coming from behind had to shoot into the wind, so in effect there was a 624-mph airspeed difference in what each opposing bullet had to bore through.

Even with the same caliber round, the PV-1's effective gun range would exceed the Zero's by a significant margin. Also, when chasing a bomber, the Zero was a stationary target as it closed, so the turret gunner had an easy time hitting it.

The Japanese liked to push ahead of the bombers and make frontal attacks, with both aircraft facing the same gun range conditions. The Japanese pilots also tried to execute slashing attacks from the side to mitigate the range advantage and make themselves a moving target.

Between the weather, enemy fighters, and anti-aircraft batteries, the Empire Express runs were fraught with dangers. Pilots with damaged engines were not left with many options—it was either ditch in the sea or crash-land in desolate Russia. Combat conditions were savage.

On August 19, 1944, Lieutenant Jack R. Cowles and crew took to the air for a daylight strike against Paramushiro. He spotted 16 Japanese ships at an-

RALPH WETTERHAHN

Their blades bent but not damaged, the propellers were most likely not operating during the crash-landing.

chor in Kakumabetsu Harbor and bored in at minimum altitude.

Japanese anti-aircraft batteries opened up. A shell ripped through Cowles' port wing but failed to explode. Tracers converged in a wicked crossfire. Windows were knocked out, the radio was smashed, the navigator's sextant was shattered, a 25-mm shell exploded in the tail gunner's position, and the cockpit gunsight was knocked out. Gasoline began spurting onto the fuselage floor. Another 25-mm shell exploded in the right engine. And then the fighters came.

Cowles jettisoned his external wing tanks to lighten the load as three Japanese Oscar fighters came roaring in, guns blazing.

During these attacks, bullets poured steadily into the airplane; one creased an ensign's jacket and another passed between Cowles' legs. Gunner John R. McDonald, nearly out of ammunition after 20 attacks, shot down an Oscar. The other fighters then broke off the engagement.

At that point, the Ventura neared Russia, its engine sputtering because of damage to a fuel transfer pump. The airplane was beyond help; Cowles crash-landed near the coast of Kamchatka, tearing off a large section of the tail. When the fuselage came to a stop, it burst into flames. The crew, trapped by a jammed cabin door, scrambled to safety through the split in the fuselage. All five men survived.

As radioman Rudolph Toney and the rest of the crew followed Cowles toward the beach, three armed Russian soldiers appeared. Cowles knew only one useful Russian word.

"He yelled 'Americanski!' " Toney recalls today. "A Russian grabbed him and bear-hugged him like he was a long lost brother." The crew was interned for six months and repatriated.

The crash site of PV-1 number 49507 is 20 miles to the south of the remains of Walt Whitman's airplane. At the site today, the ruins of war are preserved amid the barren beauty of Kamchatka.

COURTESY DONNA LEWALLEN-ATKINS

NATIONAL ARCHIVES

Donald Lewallen,navigator on number 34641, whose remains were later identified. Right: Commodore Leslie Gehres, hands on hips, devised the Empire Express.

Fire had destroyed much of the aircraft. One engine showed evidence it was still putting out power at impact.

In September 1944, U.S. Army Air Force bombers were again attacking in force over the Kuriles, operating from Alexei Point on Attu. With the Army and Navy now flying missions, the Japanese became convinced that an invasion from the north was planned. The Japanese took measures to further improve defenses, drawing forces away from other battlefronts.

Historians' estimates vary: From one-sixth to one-quarter of the Japanese air arm was diverted to the Kuriles to defend against an anticipated invasion from Alaska.

The Empire Express had done its job. The cost was high, considering the small size of the units. Thirty-eight PVs—including Whitman's—were lost during the campaign, along with 41 Army Air Force bombers. Many disappeared without a trace, leaving families and friends with heartbreaking uncertainties.

Every so often, one of these mysteries is solved.

The Prisoner of War/Missing Personnel Affairs Office team sent to investigate the Kamchatka crash sites included ordnance experts to defuse live ammunition, Russian and U.S. military brass, a forensic anthropologist, and a mortuary affairs specialist to handle human remains.

The site had attracted the attention, and tampering, of Soviet authorities. In 1962, an engineer on a geologic survey spotted the aircraft, and the KGB sent a team to investigate the site.

The team removed the machine guns, cut open the fuselage, hoisted out live bombs, and tried to blow them up. Because Kamchatka was a highly restricted area during the cold war, the area remained relatively undisturbed. Russian nuclear "Boomer" submarines still operate out of Petropavlovsk.

The U.S. team reached the crash site via a Russian Mi-2 helicopter in August 2000. As it turned out, they had no problem making the identification because Whitman's airplane had survived the

NATIONAL ARCHIVES

The aircraft discovered in Kamchatka sit on the ramp at Attu in March 1944, weeks before their fatal missions. Number 34641 is in the background.

crash without bursting into flames.

Examining the wreckage, the team was able to reconstruct the final minutes of Whitman's mission. Both engines showed heavy battle damage, caused by fighter attacks from above before the Ventura could make its bombing run.

Oil from a punctured prop spinner spilled over the engine's hot cylinder heads, leaving a dark smoky trail as the airplane struggled to maintain altitude. The crew desperately tried to reach Petropavlovsk, but impending engine failure forced them down.

The lack of damage to the propellers proves the blades had windmilled to a halt. Touchdown was level—the Ventura had been crash-landed, not simply crashed.

However, survivors would then have had to face the unforgiving elements, isolated and unaided. They perished in the frozen wilderness.

Department of Defense officials made a second visit to the area to recover the human remains from Whitman's airplane for identification and subsequent burial in Arlington National Cemetery, outside Washington, D.C.

Not every body was found on board—the skeletal remains of three crewmembers were positively identified, with other items, like a personalized jacket, indicating that others likely died at the site as well.

Using DNA analysis, researchers were able to identify Second Class Petty Officer Donald Lewallen among the fallen.

"There was never a funeral," says his daughter, Donna Lewallen-Atkins, who was two years old when he disappeared. "There was always doubt. I always prayed he'd come back."

Hearing the fate of her father's airplane was an emotional moment. "I was surprised," she recalls. "I was so choked up I could hardly speak. I thought he was lost at sea. My aunts and uncles always wondered if he had been captured by the Japanese."

The mystery is solved, but a larger question remains: Why these men emerged from World War II with so little recognition.. What they accomplished was not a sideshow of the larger war. To take the fight to the Japanese, they had to move their bases westward into the harsh north Pacific.

The Japanese expended considerable manpower and material constructing naval facilities and airfields, as well as positioning hundreds of antiaircraft batteries, ships, and airplanes.

Walt Whitman and his crew, like all those who flew unheralded over the frozen waste of the north Pacific, earned their trip home.

THE KGB SENT A TEAM to invesigate the site. They removed machine guns, cut open the fuselage, hoisted out LIVE BOMBS, and tried to BLOW THEM UP.

SIGHTINGS

In aerospace design, form follows function. Not that the forms can't be aesthetically pleasing, whether they're the guide vanes in a wind tunnel (right), a model of a hypersonic "wave rider" (below), or a circa-1937 wooden model of a Stearman 85 (bottom). The Art Institute of Chicago and NASA highlight these and other eye-catching artifacts in their touring exhibit, "Aerospace Design: The Art of Engineering From NASA's Aeronautical Research," which runs at Seattle's Museum of Flight from May to September. For more information on the exhibit, go to *www.artic.edu/aic/exhibitions/nasa/overview.html*.

NASA (3)

Aviation's Baby Boom

Wings of Change

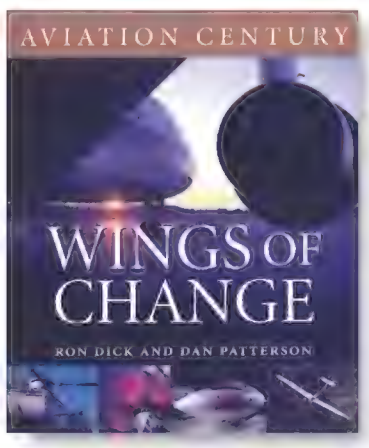
by Ron Dick and Dan Patterson. Boston Mills Press, 2005. 288 pp., $39.95.

DAN PATTERSON

The latest volume of Aviation Century *highlights General Billy Mitchell's career. His medals and uniform (this one is thought to be the one he wore at his 1925 court-martial) and other memorabilia are at the U.S. Air Force museum in Dayton, Ohio.*

In the heady days after World War II, the convenience of airplanes became available to travelers everywhere. This era may not have featured the kind of breathless exploits of the 1920s and 1930s, the Golden Age of Aviation, but it did witness the birth of commercial aviation, bringing flight to millions of the formerly earthbound. In 1945, airlines carried more than six million American passengers. A decade later, that number would double.

This industry did not just appear—designers created amazing new machines to bring the miracle of air travel to the masses. In *Wings of Change*, the fourth volume in the *Aviation Century* series, Dan Patterson and Ron Dick, an *Air & Space/Smithsonian* contributing editor, chronicle the people and companies that changed the world with their struggle to design better aircraft and keep them flying, literally and financially.



The five-volume *Aviation Century* series includes *The Early Years*, *The Golden Age*, and *World War II*. The last installment, covering the Jet Age and the future of aviation, is expected this fall.

As experienced aviation chroniclers, the pair do a good job of showing the international dimensions of this momentous development, highlighting British, French, and Swedish enterprises and the stiff competition that marked the early aviation industry. Companies struggled to keep up with one another's advances, producing a wealth of interesting designs and stories. Chapters span a wide range of areas, including rotorcraft, airships, personal-aviation trends, and the history of research and development. A nice addition is a chapter profiling more than 30 test pilots, some of who are undeservedly obscure (let's hear it for Peter Twiss!).

The best photos are reserved for two-page breakouts that focus on specific airplanes. Archival black-and-white images also capture variants of experimental or pivotal aircraft, including shots of unique helicopter designs. Other shots border on the banal, such as an unimpressive collage of shots from a "parade of planes" in Ohio that tells no discernible story and fails to capture even one whole airplane among five photos.

Still, the book provides a vivid and interesting history of the birth and boom of commercial aviation.

—Joe Pappalardo is an Air & Space *associate editor.*

High-Speed Dreams: NASA and the Technopolitics of Supersonic Transportation, 1945-1999

by Erik Conway. Johns Hopkins University Press, 2005. 369 pp., $49.95.

High-Speed Dreams is a concise and thoroughly fascinating history of the train wreck that was the U.S. supersonic civil transport programs. Conway, a historian at NASA's Jet Propulsion Laboratory in Pasadena, California, skillfully simplifies the vexing technological and ecological issues involved in this history while documenting the layers of political infighting, self-serving agendas, and industry doublespeak that contributed to dooming the prospects of commercially viable supersonic transports.

Assumptions about speed, progress, and national prestige in the United States and Europe are carefully detailed. French President Charles de Gaulle believed large, state-funded programs like the Anglo-French Concorde SST would transform his nation into a world technology leader. The British signed up for the Concorde in part because they thought it would defeat French objections to their admission to the common market (it didn't). In the United States, the airline industry and Boeing publicly pushed the SST even though internal studies showed that it was highly unlikely to ever be profitable.

Conway documents a turbulent four decades of research, including the extraordinary advances that occurred over the last twenty years despite all the turmoil. At times, however, despite his best attempts to simplify things for non-engineers, Conway's prose can get a little thick.

In the end, those pushing a high-speed agenda saw very few of their dreams come true. "Speed is only politically suitable if it comes with competitive economics and acceptable environmental impact," writes Conway.

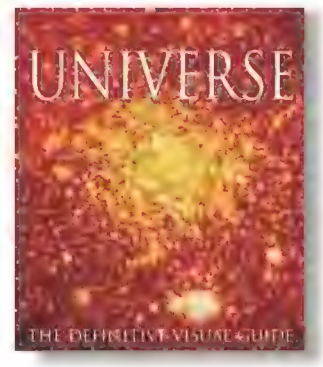
For many, the dreams died not with a sonic boom, but with a whimper.

—Mark Huber is the author of Mach 1 for Millionaires *(p. 40).*

Universe: The Definitive Visual Guide

by Robert Dinwiddie et al. Dorling Kindersley, 2005. 512 pp., $50.00.

If you know a three-year-old with a good grasp of the animal kingdom or a seven-year-old able to identify dozens of species of dinosaurs, chances are you're already familiar with the reference guides from DK Press. The lavishly illustrated tomes provide information overload for readers of all ages, from picture books for toddlers to vast encyclopedias like the recent *Animal* and *Earth* guides, produced in collaboration with the Smithsonian Institution.



As if all of planet Earth weren't a broad enough field of study for one book, the publisher's latest far-reaching guide takes on the entire universe.

Equal parts field guide, science text, and coffee table art book, *Universe: The Definitive Visual Guide* gives an overview of the history of astronomy and space travel, presents complex information in simple charts and graphics, and uses stunning photography and imagery to lead readers on a planet-by-planet voyage through our solar system, the Milky Way, and galaxies

WHAT'S NEW ON DVD

Hubble: 15 Years of Discovery

DVD. Produced by the Hubble European Space Agency Information Center. 133 min. Includes bonus material and separate audio CD. $24.95.

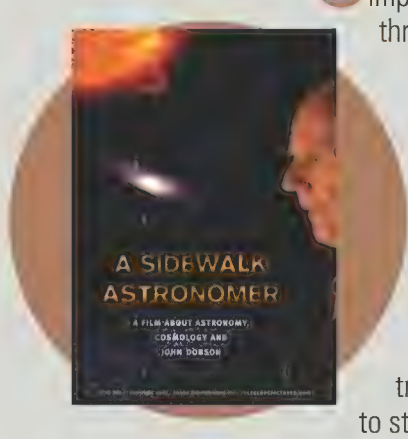
We'll never know what Carl Sagan would say about *Hubble: 15 Years of Discovery*. But one can safely assume that Sagan wouldn't be very impressed by this European Space Agency attempt to replicate his wildly popular "Cosmos" TV series.

The three-dimensional computer animations in this film are exceptional. In fact, sometimes it's hard to tell the real Hubble images from the simulated ones. And that's too bad. To date, Hubble has orbited Earth nearly 100,000 times and shot over 700,000 images. With all that in hand, the producers could have created a first-rate DVD without needing all the special effects.

—Dale Smith is a freelance aviation writer in Florida.

A Sidewalk Astronomer: A Film About Astronomy, Cosmology and John Dobson

DVD. Jacobs Entertainment, Inc. 2005. 78 min., $34.95.



John Dobson approaches astronomy like a street preacher, imploring passersby to "just take a look" at the wonders of the sky through his own ramshackle, homebuilt telescope. Those who stop to look inevitably gasp in amazement. It's a big universe out there, and Dobson wants to the world to know it.

Ninety-year-old Dobson is the original sidewalk astronomer. A former monk, Dobson invented a type of inexpensive telescope and urged his growing number of followers to build others like it and take them to the masses. Other than that, there's not much solid biographical information about him in this *cinema verité* documentary. But what's here is wonderful: Dobson is shown traveling across the country explaining how the cosmos works to students and the everyday person. "Everything we know about the universe has been figured out by people as stupid as ourselves," he says. "If they can figure it out, we can figure it out." His demeanor, and the camera zooming in on ever-expanding photographs of the infinitesimal universe, make you want to give it a shot.

—Phil Scott is the author of Hemingway's Hurricane *(McGraw-Hill, 2005).*

beyond. Along the way, brief bios of astronomers, space travelers, and scientists—as well as dozens of figures from ancient mythology—flesh out the story of our understanding of space and our many discoveries about the cosmos.

Universe closes its journey by acknowledging that, impressive as it is, even *The Definitive Visual Guide* is no match for participating in the experience of staring into the night sky in wonderment: The final third of the book is devoted to beautiful constellation maps and monthly sky guides to help Earth-bound spectators enjoy the view and make discoveries of their own.

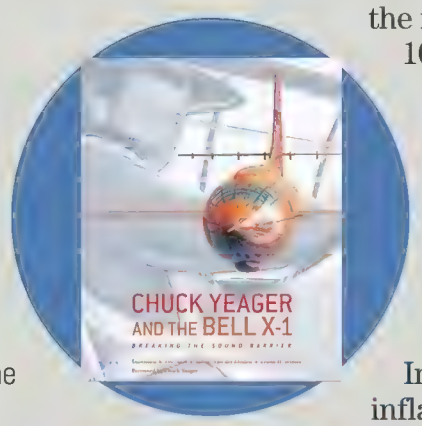
—Colin Bane is a freelance writer in Washington, D.C.

EXCERPT

Chuck Yeager and the Bell X-1: Breaking the Sound Barrier

by Dominick A. Pisano et al. Abrams, 2006. 125 pp., $22.50.

This book—co-authored by Dominick Pisano, a curator in the Aeronautics Division at the National Air and Space Museum; F. Robert van der Linden, curator of special-purpose aircraft and commercial aviation in the Museum's Aeronautics Division; and Frank Winter, curator of rocketry in the Space History Division—provides new insights into the history behind the Bell X-1 and Captain Charles "Chuck" Yeager. This excerpt is from a chapter called "The Flights," and details the many and varied adventures of the famous little orange airplane, aside from its celebrated 1947 sound-barrier-busting flight.



When first conceived, the Bell X-1 was designed for a conventional takeoff. The need for maximum performance given the limited range of the rocket engine meant that the X-1 required an air launch. Lawrence Bell and others, however, always wondered how the X-1 would perform from a ground launch. This was also attempted to silence ill-informed critics who inferred that the X-1 was not a true aircraft as it did not take off from a runway. Air Force commander General Hoyt Vandenberg and Captain Charles "Chuck" Yeager readily agreed to the flight. With the aircraft modified with improved tires and brakes, and the fuel load set at 75 percent capacity to keep the aircraft's weight under 10,000 pounds, Yeager took off from Muroc on January 5, 1949, and climbed to 23,000 feet in only one hundred seconds. His speed was not recorded. It was the first and only time a rocket-powered research aircraft took off conventionally.

The first Bell X-1 was also responsible for an unexpected first. With Major Frank Everest at the controls not long after his record-setting high-altitude flight, the first X-1 took off on August 25, 1949, in an attempt to break the recent mark. As the aircraft climbed above 65,000 feet, the cockpit window cracked and the cabin suddenly lost pressure. Immediately, Everest was tightly squeezed as his partial pressure suit inflated, saving his life; he quickly shut off the engines and descended to a lower altitude. Yeager was flying one of the chase planes that day and was deeply concerned when his radio calls to Everest went unanswered. Fortunately, Everest could not speak until he reached a lower altitude and the suit deflated. This was the first time in history that a pilot's life was saved by a pressure suit of any kind.

WORTH NOTING

What's Out There: Images From Here to the Edge of the Universe

by Mary K. Baumann et al. Duncan Baird Publishers, 2005. 184 pp., $29.95.

An awe-inspiring collection of photogenic phenomena in our universe, as captured by today's working telescopes and probes.

Boeing's B-47 Stratojet

by Alwyn Lloyd. Specialty Press, 2005. 276 pp., $39.95.

A dry but detailed chronicle of America's first strategic jet bomber, the precursor to the B-52 and an unsung hero of the early years of the cold war.

Mikoyan MiG-31

by Yefin Gordon. Specialty Press, 2005. 224 pp., $44.95.

Previously unpublished photos and diagrams, as well as a detailed history from a knowledgeable author, make this book a must-have for MiG fans and foes.

YOUNG READERS

The Adventures of Vin Fiz

by Clive Cussler. Philomel Books, 2005. 160 pp., $15.99.

Clive Cussler's *Vin Fiz* is an excellent book in which twin brother and sister Lacey and Casey take flight in a Wright brothers' plane. The book has a twist of history, magic, and adventure, which will hold readers until the last word. I highly recommend this book to young readers. It's not Cussler's usual political or military action/adventure, but adults will enjoy it also.

—Matthew Mann is a 12-year-old Clive Cussler fan.

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Ever since the first human went into a dark cave and built a fire, people have realized the importance of proper indoor lighting. Unfortunately, since Edison invented the light bulb, lighting technology has remained relatively prehistoric. Modern light fixtures do little to combat many symptoms of improper lighting, such as eyestrain, dryness or burning. As more and more of us spend longer hours in front of a computer monitor, the results are compounded. And the effects of indoor lighting are not necessarily limited to physical well-being. Many people believe that the quantity and quality of light can play a part in one's mood and work performance. Now there's a better way to bring the positive benefits of natural sunlight indoors.

The Balanced Spectrum® floor lamp will change the way you see and feel about your living or work spaces. Studies show that sunshine can lift your mood and your energy levels. But as we all know, the sun, unfortunately, does not always shine. So, to bring the benefits of natural daylight indoors, use the floor lamp that simulates the full spectrum of daylight. You will see with more clarity and enjoyment as this lamp provides sharp visibility for close tasks and reduces eyestrain.

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We've looked at lots of lights, but this one offers the benefit of dual light levels of 27 and 18 watts of power, equivalent to 150-and 100-watt incandescent bulbs. This lamp has a flexible gooseneck design for maximum efficiency, with an "Instant On" switch that is flicker-free. The high-tech electronics, user-friendly design, and bulb that lasts 10 times longer than an ordinary bulb make this lamp a must-have.

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**Source: "Lighting the Way to Energy Savings"; 1999

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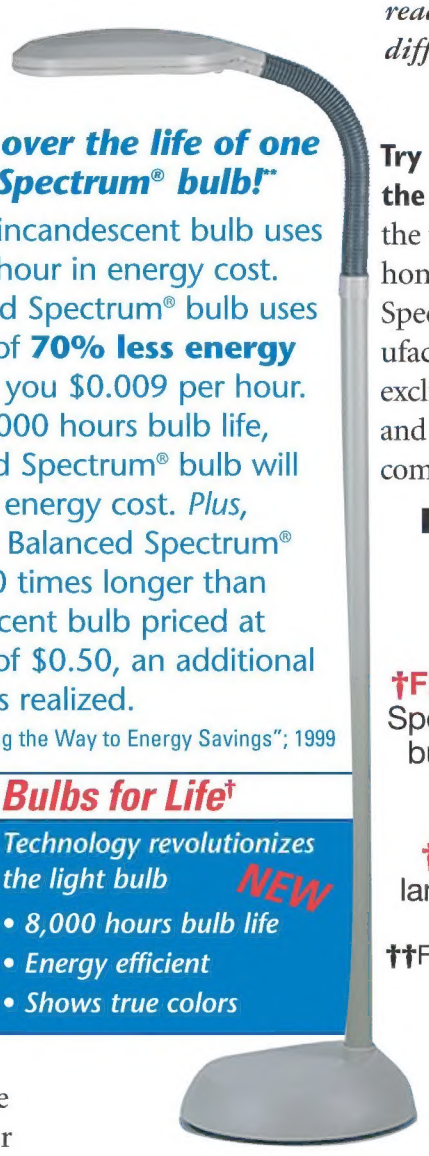

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Donna E.
Scranton, PA

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CALENDAR

February 12
Sally Ride Science Festival. Workshops for school-age girls, their parents, and educators, as well as a talk by America's first woman in space. San Diego Aerospace Museum, Balboa Park, San Diego, CA, (619) 234-8291, *www.aerospacemuseum.org*.

March 10–12
Valiant Air Command's Tico Warbird Airshow. Vintage military aircraft on static display and flight demonstrations by a U.S. Air Force F-15 and F-16. Valiant Air Command Museum, Titusville, FL, (321) 268-1941, *www.vacwarbirds.org*.

March 18 & 19
California Capital Airshow. The U.S. Navy Blue Angels will perform. Mather Airport, CA, (916) 874-0780.

Organizations wishing to have events published in Calendar should fax press releases to (202) 275-1886; e-mail them to editors@si.edu*; or mail them to Calendar,* Air & Space/Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012.*

CREDITS

Collision Course. Chris Koelzer is an F/A-18 pilot in the U.S. Marine Corps Reserves and an aerospace consultant.

Pilot 1, Scientists 0. Douglas Warrick, an assistant professor of zoology at Oregon State University, now studies live birds—in particular, their flight. He's been a pilot since he was 17, but some part of him claims he was a scientist first.

Go Ballistic. Frequent *Air & Space/Smithsonian* contributor Craig Mellow would love to write about a ride into space for a magazine that will pay his travel expenses.

Steichen's Navy. T.A. Heppenheimer has been writing for *Air & Space* since 1986.
Further reading: *Steichen at War,* Christopher Phillips, Harry N. Abrams, Inc., 1981.

Didi & Sigi's Excellent Collection. Bettina H. Chavanne is an associate editor at *Air & Space.*

Mach 1 for Millionaires. Pilot and author Mark Huber typically cruises at Mach 0.158 in a Cessna 172.

MGM Special: Ryan B-1 Brougham. Writer and educator Gail Hearne lives in central Arizona's Mogollon (pronounced "muggy-own") Rim country.

By Stars, Beacons, and Satellites. Peter Garrison has flown a single-engine airplane across both the Atlantic and Pacific using only a compass and a clock for navigation, and arrived where he intended to three times out of four.

Going Up? While he awaits construction of the first space elevator, Michael Milstein covers the environment and science for *The Oregonian* in Portland.
Scott Highton, a photographer based in the San Francisco Bay area, is authoring a book on virtual reality photography.

Fire and Ice. Ralph Wetterhahn has turned his magazine reporting into four television documentaries and three books, including *The Last Flight of Bomber 31* and *The Last Battle: The Mayaguez Incident and the End of the Vietnam War.* He is now researching the fate of U.S. Air Force F-86 Sabre pilots who disappeared in the Soviet Union during the Korean War.

FORECAST

In the Wings...

CAROLINE SHEEN

Blériot XI replica, Cerny, France.

Le Airshow
If there's one thing the French are more passionate about than their wine, it's their aviation history.

Apollo on Steroids
Four astronauts, not two; the ability to land anywhere on the surface; a building block for a future moon habitat: What will Lunar Lander 2.0 look like?

Orchestrated Hell
A reconsideration of Edward R. Murrow's famous 1943 broadcast after flying aboard a Lancaster bomber on a mission to Berlin.

What Makes a Winner?
Past champions of the Reno air races spell it out.

ON THE WEB SITE

www.airspacemag.com

Good science fiction sometimes spurs scientific advancement. The idea of a space elevator, for example (see "Going Up?" p. 58), first appeared in a work of fiction by renowned author Arthur C. Clarke. To see where it all began, read excerpts from his novel *Fountains of Paradise*, in which a character envisions and builds a space elevator from the Indian Ocean a to geostationary orbit. Advancing the case for such a structure, the book is detailed on concept but light on solutions that would help engineers actually build one. Also on the Web site: more photos of the Flying Bulls collection of vintage aircraft (see "Didi & Sigi's Excellent Collection," p. 34) and more from the impressive oeuvre of Edward Steichen (see "Steichen's Navy," p. 26).

The *Really* Red Eye

When a Boeing 777-200LR landed in Heathrow Airport on November 9, 2005, having flown 13,422 miles (in 22 hours and 42 minutes) from Hong Kong, it set a new record for distance without landing—and struck fear into the hearts of coach-class fliers everywhere.

Boeing's goal was to prove that its aircraft has the longest range of any commercial jet in the world. Boeing very nearly set the record for the longest flight ever made by any jet aircraft, but Steve Fossett's around-the-world flight in the Virgin Atlantic Global Flyer beat the company to that record by a couple of months.

GEOFFREY THOMAS

Co-pilot Rod Skaar probably wishes he'd remembered his sunglasses as the morning sun floods the cockpit.

Prior to Boeing's Hong Kong-to-London hop (and Fossett's record flight), the long-distance record was held by a Boeing B-52H Stratofortress that flew 12,532 miles in 1962.

"Our flight may have been shorter [than Fossett's], but it was much more comfortable," says Rod Skaar, a Boeing production test pilot who worked on the record project, and the chairman of the National Aeronautic Association's contest and records board.

Boeing's 2005 flight also shattered the old record for aircraft weighing more than 300,000 kilograms (about 661,000 pounds), which was held by a Boeing 747 and had stood since 1989. That flight, from London to Sydney, covered 10,588 miles without landing. Boeing also wanted to exceed its own longest flight, even though it wouldn't break that record (the airplanes were in different weight classes): A 777-200ER flew from Seattle to Kuala Lumpur in 1997, flying 12,455 miles without landing.

"There's not much point in going more than halfway around the world if you're trying to get from point A to point B," says Skaar. "This could be the longest flight of a commercial transport for, I would say, a very long time."

Starting the record flight in east Asia allowed the aircraft to head out over the Pacific Ocean and catch a strong tailwind. The start of the flight was crucial, says Skaar. "With a busy airport like Hong Kong, you can spend a lot of time waiting for clearance to take off and taxi on the ground, which wastes a lot of fuel."

The airplane took off with a crew of 12—eight of them pilots—and 23 passengers, including media and NAA observer Art Greenfield, who usually administers the contest and records department at NAA headquarters in Alexandria, Virginia.

"That's one of the fun things about setting the record," says Suzanna Darcy-Hennemann, project pilot leader for the record flight. "You do all this work and you get a great reward at the end."

—Dustin Gouker

LOGBOOK

Record-Setting Airliners

On October 4, 1958, Britain's BOAC became the first commercial airline to cross the Atlantic when two of its de Havilland Comet 4s took off—one from New York, at the same time as another from London. Both aircraft were full of passengers.

A few weeks later, on October 26, Pan American World Airways launched its own transatlantic jet service with a flight of a Boeing 707 between New York and France.

At the time, neither the Comet 4 nor the 707 had the range to complete the journey without refueling, and both aircraft stopped in Gander, Newfoundland.

The first trans-Pacific commercial jet flight was made by a Qantas Airlines 707 in 1959, and linked Sydney, Australia, with London. The aircraft had to make fuel stops in Fiji, Honolulu, San Francisco, and New York.

In 1965, a Qantas 707-338B finally made the long hop between Sydney and San Francisco in one flight—the four-engine jet took 14 hours and 33 minutes to complete the 7,424-mile journey.

The first jumbo jet, Boeing's 747, was rolled out with great fanfare in September 1968, and made its first flight in February 1969. The selling point of the 747 was its range. It was first advertised as being able to hold 375 passengers and fly 5,700 miles without refueling.

In January 1970 it was again Pan Am that made history with its Boeing 747, flying direct from New York to London. TWA ushered in 747 service between New York and Los Angeles.

Since the late 1950s, each airliner that has rolled off the production lines has boasted greater range than its predecessor, a competition that continues to this day—most notably between Boeing's 777 and Airbus's A-340.

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa.aero *or call (703) 527-0226.*